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A PRELIMINARY STUDY OF THE INSECT PESTS OF COTTON IN THE PHILIPPINES WITH SUGGESTIONS FOR THEIR CONTROL

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TEN PLATES

INTRODUCTION

Twelve years ago, Mr. H. E. Woodworth (1922), then professor of entomology in the College of Agriculture, University of the Philippines, Los Baños, in an article on the local cotton boll weevil (*Amorphoidea lata*), stated that the subject of cotton pests had apparently received little attention in the Philippines. It was late in 1933 when the subject was taken up for more comprehensive study in view of the widespread interest in the raising of cotton for the purpose of supplying local demand. Accordingly, it has been deemed necessary and timely to put together available information and such local data gathered so far on the various insect enemies of the plant. The cotton planter should at least get acquainted with them, for insects, here in the Philippines as in other countries, constitute a most important factor to contend with. The growing of cotton, a dry-season crop, coincides with the abundance of some of the species of insects affecting the plant—aphids and mealy bugs,

for instance. Even suggestions as to control may be of value to all concerned in minimizing the ravages of the pests of cotton. After this preliminary paper, it is the plan to present, as our investigations progress, a more detailed account of each of the insects on cotton, beneficial or injurious.

The planter should pay more attention to the proper culture of cotton so as to produce vigorous and hardy plants, in order to minimize the expenses for the control of pests and diseases. Among the factors to be considered are the most suitable variety or strain to plant, right time of planting, proper tillage or such practices that will properly conserve the soil moisture, for lack of water makes the plants stunted. There is probably no other annual crop in which moisture, as a climatic or environmental factor, requires more attention than in the case of cotton. Baltazar (1934), for instance, makes the following statement as to the climatic requirements of cotton in which the question of moisture is stressed:

> When young, the crop flourishes best in warm, moist weather. Occasional showers, or light rainfall during the pre-blooming period is very beneficial for the vegetative development of the plant, but too much rain or too much water in the soil tends to increase weeding expense and may cause the plants to produce too much of the woody parts, possibly at the expense of fiber production. On the other hand, severe drought stunts the plant, matures it too early and consequently gives a low yield as the staple produced is small and light. From the time the plant is about to bloom, warm, dry weather is best for the production of a superior heavy-staple crop and for convenient harvesting.

Espino (1920) and Roxas (1931) in their articles on cotton culture likewise give due emphasis on the moisture requirement of the cotton plant.

Moisture, apparently, has an important bearing on insect infestations, by sucking insects in particular. Certain authors, Mumford and Hey (1930), for instance, in an article, entitled "The water balance of plants as a factor in their resistance to insect pests," observed that a disturbed water content, from whatever source, rendered the cotton plant more susceptible to the attack of sap-feeding insects, such as various species of thrips. These authors cited, among those of other workers, their extensive observations in California, where cotton plants receiving an optimum water supply did not have large numbers of thrips, whereas the plants suffering from water shortage seemed definitely more attractive to thrips. While the matter of the water balance of plants as a factor in their resistance

to insect pests and the "water duty practice" as discussed by Wardle (1929), in relation to insect infestations, are subjects that still need to be extensively investigated in connection with individual cases, yet there is certainly no question as to the importance of maintaining a reasonably sufficient moisture in the soil or conserving what is present in the soil, to insure a paying crop of cotton.

In the control of cotton insects—and those of other crops as well—it is hardly possible to depend on any single control method alone. Therefore, in addition to chemical and biological (the employment of parasites and predators) methods of control, the value of hand or mechanical methods should not be underestimated, especially where labor is cheap. The control of leaf eating caterpillars by hand-picking when at first greatly localized, and by simply removing the leaves or parts of the stems affected by initial colonies of mealy bugs may save the planter a great deal of labor and expense. So, also, is the persistent collection and destruction of certain adult insects when they first appear. In the case of the native cotton boll weevil, when the insects begin to appear on the first or early flowers, prompt collection and destruction of the young bolls that have fallen to the ground will materially help to prevent greater infestatations later. If the fallen bolls are not picked up promptly and persistently the larvæ or grubs will soon leave them, dig into the soil, and pupate and the resulting beetles will infest all new and succeeding flowers.

BITING OR CHEWING INSECTS AFFECTING COTTON

THE COTTON BOLL WEEVIL (AMORPHOIDAE LATA Motsch). Plate 1, fig. 1.

This is one of the most injurious insect pests of cotton in the Philippines. As the name indicates, the insect is with a snout or beak at the end of which are the teeth and mandibles and other mouth parts. It is a small, dark brown insect, being only from 3 to 4 millimeters long. According to Dammerman (1929), it is also found in India and Java. It seems that it has been known in the Philippines since the early days of scientific agricultural work here under the American régime, as Espino (1920) quotes the following from an early report of the old Bureau of Agriculture:

> . . . during the development of the bolls, they were profuse and very fair crops would have been obtained had it not been for the ravages of weevils and other insect pests. The weevil trouble assumed such a serious stage that a boll rarely reached the picking stage in a perfect condition.

It is apparent that no species other than *Amorphoidea lata* was involved as no other species has been found on cotton, although the identity of the pest, it seems, was not recorded until after several years later. Schultze (1915) noted that *A. lata* was very injurious to cotton.

At Singalong, Manila, the insects have been observed to gather in the newly opened flowers in the morning, usually between 7 and 10 o'clock. The female punctures the young bolls and lays its eggs in the pistil and the resulting larvæ or grubs eat the young seeds and other soft part of the seed capsules. Because of the injury, the young bolls soon fall off.

Life history and habits.—Professor Woodworth (1922) studied to some extent the life history and habits of the insect at the College of Agriculture, Los Baños, but did not suggest any control measure. He found out that under conditions there, the eggs hatched in 1 to 3 days, the average incubation period being 1.5 days. The larval or grub period ranged from 5 to 9 days and the pupal from 3 to 5 days. Its life cycle there, therefore, from the time the eggs are laid to the time the adult beetles emerge, is from 9 to 17 days, the average being 11.8 days.

Professor Woodworth also found that the insect also bred in the flowers of a tree, known in Tagalog as "makarapas" (*Thespesia lampas*) and that the beetles fed on the flowers of other plants related to cotton.

The life history of the insect as observed in the Entomology Laboratory in Manila are as follows:

Incubation period	2 to 3 days
Larval or grub	6 to 11 days
Pupal stage	2 to 5 days
Emergence to first laying of eggs	1 to 4 days

From these data, the life cycle in Manila, therefore, from the time the eggs are laid to that when the adults begin to lay eggs is from 11 to 23 days or an average of 17 days.

Descriptions.—The following descriptions of the different stages of the boll weevil are in the main adapted from Professor Woodworth's article:

Egg.—Smooth, pearly white, elliptical to ovoid; average size 0.64 millimeter long and 0.44 millimeter in diameter. (Plate 3, fig. 1.)

The eggs are laid in the tissue of the opened flower, in the sheath of the ovary or staminal column. The female excavates a small cavity in the tissue of the staminal sheath with her snout, and reversing her posi-

tion, deposits a single egg in this cavity. Several eggs may be deposited in this flower. An average of five eggs per flower has been found.

The larva.—Wrinkled, grayish-white, crescent-shaped, apodous or legless, with a few scattered darker hairs. Head slightly smaller than the body, brown, pale when newly hatched and darker later. About 4 millimeters long and 1.2 millimeters at greatest width when full grown.

Pupa.—Naked and resembles the adults as to form; grayish white with a few scattered darker hairs. Eyes, chocolate brown; mandibles, dark. Elytra or outer wings much darker than the rest of the body.

Adult.—Head, minutely and shallowy pitted, pale to reddish brown and sparsely pubescent; eyes, lateral, convex and nearly circular. Rostrum or beak as long as prothorax; sides, parallel. Antennae, light brown arising from the middle of the rostrum, elbowed, or geniculate; the first segment or scope almost as long as all the succeeding, resting in a groove on the basal half of the rostrum and reaching to the eye; the club conspicuously broader than funicles. Prothorax 1½ times as broad as long; sides, rounded, broadest in middle, narrowed slightly behind and strongly constricted anteriorly, minutely pitted, and pale, with fine sparse pubescense below. Scutellum present. Elytra, ovate, chocolate in color, with golden brown scales, striate and finely pitted. Abdomen below, and legs concolorous with thorax, length 3.5 millimeters, breadth 1.7 to 2 millimeters.

At Singalong, Manila, as many as five larvæ or grubs have been found in a fallen boll. When full grown the larvæ leave the bolls and dig into the soil where they pupate.

Control.—It is thus advisable that the young bolls that fall to the ground be collected every day and burned so as to prevent the pest from increasing rapidly.

Since the beetles congregate or gather in the newly opened flowers, as many as over thirty having been found in one flower, they should be collected and killed. If this is done persistently, especially when the early flowers appear, the damage can be greatly minimized.

In the United States, dusting with calcium arsenate alone is generally employed to control the notorious boll weevil (*Anthonomus grandis* Boheman), a native of Mexico and Central America. The weevil, besides feeding on the cotton leaves, drink the dew on the leaves. The application of calcium arsenate dust on the plants thus results in poisoning and killing the insects and the method has become a general practice among American cotton growers, although the method is not without its drawbacks, as indicated by the work of Folsom and Bondy (1930). They found that excessive applications of calcium arsenate were often followed by heavy infestations of the cotton louse (*Aphis gossypii* Glover).

So far, it has not been found whether the local boll weevil (*Amorphoidea lata* Motsch.) has similar habits as the Mexican boll weevil mentioned above. In fact Woodworth (1922) failed to notice any attack on the leaves and stems. Hence, dusting entire fields with calcium arsenate to control this pest cannot as yet be recommended. However, from our field tests, we have found that dusting the beetles congregated in the newly opened flowers in the morning with a 50–50 mixture by volume of calcium arsenate and "gaogao" (this poison has been extensively employed locally for dusting against locust hoppers) killed the beetles in about half an hour. It would seem that if the insects are abundant on the early flowers, calcium arsenate, either alone or mixed with "gaogao" or other suitable carriers, may be employed. Some cotton plants may also be planted ahead of the main crop and the flowers used as trap by killing the bettles that gather in them by dusting or handpicking.

The bug (*Geocoris tricolor*) has been found to prey on the beetles and on mealy bugs. The insect (Plate 10, fig. 5) is shiny black and is about 5 millimeters long and 2.5 millimeters wide. The dorsal surface of the head is brownish yellow and the eyes are brownish red. The lower surface of the head is pale yellow and the proboscis is of the same color as the dorsal surface of the head. The first and second segments of the antennæ and the distal half of the fourth segment of the antennæ are also pale yellow, the remaining portions (the third and fifth or last segment and the proximal half of the fourth) being black. The legs and the tips of the wings are likewise pale yellow. The notal or dorsal portion of the thorax and the proximal portions of the outer wings are distinctly pitted or punctate.

THE COTTON SEMI-LOOPER OR "ABUTILON MOTH" (COSMOPHILA EROSA Hubn.). (Plate 2, figs. 1 and 3.)

This green semi-looper or measuring caterpillar has been found quite common on cotton as a leaf feeder. Judging from its work, it is capable of great injury when present in abundance. The insect is quite a cosmopolitan species. It is also found in the United States where it is known as "the abutilon moth." There the abutilon plant was found by Chittenden (1913) to be the insect's preferred host. The species is widely distributed in Asia.

Food plants.—Besides on cotton, the caterpillars have been observed to feed locally on the leaves of cowpeas. In Woodworth's host index (1921), okra is included as one of its hosts.

Life history.—The following records of the life history of the insects were obtained in the Entomology Laboratory at Singalong:

Egg stage or incubation period	2 to 3 days
Larval stage	2 to 16 days
Pupal stage	6 to 7 days

The egg (Plate 3, fig. 2).—The egg is somewhat circular in shape, about .6 millimeter in diameter, flattened, with ridges radiating from the center. The eggs are laid singly on the lower surface of the leaves. They vary in color, from light green to bluish green, and can be seen with the naked eye after one has learned to recognize them on the leaves.

The larva or caterpillar.—The caterpillar molts four times, that is, there are five instars.

The first instar caterpillars feed on the lower surface of the leaves, leaving the upper membrane or epidermis. After the first molt, however, the caterpillars consume the whole tissue.

When newly hatched the caterpillars are about a millimeter long and are pale yellow but soon become light green after feeding, and the color becomes more pronounced as they grow older. White parallel lines or markings run practically the whole length of their bodies. The full grown caterpillar is about 4 centimeters long and 3.5 millimeters wide.

The pupa.—Preparatory to pupation, the larva incloses itself by folding a leaf at one side with its silk or thread. It then sheds off its skin, which marks the real beginning of pupation. The pupa is dark brown measuring from 15 to 17 millimeters long and from 4 to 4.5 millimeters in diameter. At the end of the last segment are four spines, two of which are curved downward or ventrad. There are also four bristles which are distinctly longer than the spines and which are curved or rolled at the end (all these are parts of the cremaster).

The adult.—The adult is brownish yellow, about 1.2 centimeters long and has a wing expanse of about 3.8 centimeters. The male is of about the same size. The outer or front wings are with transverse, dark brown wavy lines and the apical or posterior half being darker, being more so in the case of the male. There is a small faint white spot or mark near the front margin of each outer wing about one-third the distance from the base.

Control.—The cotton field should be gone over often and the caterpillars which are usually localized at first should be con-

trolled promptly by dusting or spraying with either lead or calcium arsenate, preferably the latter, as it is cheaper.

For dusting, calcium arsenate may be used alone or diluted with "gaogao" or ordinary inert lime in the proportion of 1 part of calcium arsenate to 5 to 10 parts by volume of the filler or carrier. The dusting can best be done early in the morning when there is dew or when there is no strong breeze.

For spraying, use from 1.5 to 4 grams of calcium arsenate per liter of water or 7 to 14 spoonfuls (levelful) for every petroleum canful (about 5 gallons) of water. Stir vigorously before, and occasionally while spraying to keep the calcium arsenate particles in uniform suspension. A bucket pump, provided with several meters of rubber hose and with a good nozzle that will deliver the spray in a fine mist, may be employed.

Spraying with soap solution at the rate of 10 to 20 grams per liter of water ($\frac{1}{5}$ to $\frac{2}{5}$ kilo per 5 gallons or one petroleum canful of water) has also been found effective, especially on the young caterpillars.

Natural enemies.—A hymenopterous parasite (*Euplectrus* sp.) has been found to attack the caterpillars. This tiny insect (see Plate 2, fig. 1; also Plate 10, figs. 1 to 4, inclusive), which is about a millimeter long, with the head and thorax black and the abdomen and legs and antennae pale yellow, lays its eggs on the back or sides of the caterpillars and the larvae feed on the hosts by consuming their juices. When full grown, they move to the underside of the dead hosts, which are almost all skin, and fasten them to the leaves with silken threads and then pupate. This is certainly of help in keeping the pest in check. It closely resembles another parasite of the same genus previously observed to attack the larvae of the grass armyworm, *Spodoptera mauritia* (Otanes, 1925), and likewise valuable in the control of this pest.

The egg parasite, *Trichogramma minutum* Riley (Plate 9, fig. 6) introduced by Doctor Merino from the United States in March, 1934, has been found to attack the eggs of *Cosmophila erosa* in the laboratory and liberations have been made in the field.

THE COTTON PYRALID LEAF ROLLER (SYLEPTA DEROGATA Fabr.) Plate 2, fig. 2.

Another caterpillar which has been found rather common on cotton is that of a pyralid moth, *Sylepta derogata.* This is known to be an important pest in India. The insect lays its eggs singly on the underside of the leaves like *Cosmophila erosa.*

The caterpillar rolls the leaves wherein it feeds and pupates, a habit which makes the pest more difficult to control than *Cosmophila.*

The life history of the pest as worked out in the Entomology Laboratory at Singalong are as follows:

Egg stage	2 to 3 days
Larval stage	14 to 16 days
Pupal stage	6 to 7 days

The eggs (Plate 3, fig. 3).—The eggs are elliptical, about 0.6 millimeter in diameter and are laid singly, as stated previously, on the lower surface of the leaves. They are pale yellow in color and are difficult to detect on the leaves without the aid of a lens.

The larva or caterpilar.—The caterpilar molts five times, that is, there are six instars.

As in the case of *Cosmophila erosa* the first instar caterpillar feeds on the lower surface of the leaves, leaving the upper membrane. After the first molt the caterpillar begins to consume the whole tissue and to roll the leaves by means of its silky thread-like secretion.

The newly hatched larva is transparent and pale green with pale brown head. In the subsequent instars, the larva's head is brown. The dorsal portion of the prothorax is heavily chitinized and this chitinized area is brown like the head.

The pupa.—The pupa is rolled in usually at one side on the upper surface of a leaf. It is brown, turning darker when the adult is about to emerge. It is from 1 to 1.3 centimeters long and from 2.5 to 3.0 millimeters wide. At the posterior or anal end are eight stout bristles, like those of *Cosmophila,* and are also rolled or curved at the end.

The adult.—The adults are yellowish white measuring from 2 to 2.3 centimeters across the wings. On both fore and hind wings are numerous brown transverse wavy lines. The male is slightly smaller than the female and has its posterior abdomen more pointed and somewhat longer than that of the female.

Control.—1. Spraying with calcium arsenate as suggested for *Cosmophila erosa.*

2. Collecting the caterpillars.

3. Spraying with soap solution with the same strength as given for *Cosmophila* may also be practiced.

A TORTRICID LEAF ROLLER (HOMONA sp.). Plate 2, fig. 4.

Another common caterpillar which has been found on cotton is the larva of a Tortricid moth, *Homona* sp. The insect lays its eggs in masses, the eggs being arranged like scales.

Aside from cotton, caterpillars of the moth have been observed to feed on the leaves of peanut, apple, avocado and citrus.

Life history.—The following are records of the life history of the insect in the Entomology Laboratory at Singalong:

Egg stage or incubation period	5 days
Larval stage	17–18 days
Pupal stage	5–7 days

The eggs (Plate 3, fig. 4).—The eggs are small, flat, elliptical objects laid one overlapping the other. The entire egg-mass, which may contain from 99 to 250 eggs, is flat, elongated and is very smooth and glossy. The eggs are yellowish in color along the periphery, while toward the center, they are translucent.

The larva or caterpillar.—The larva molts five times before attaining full size. Like the larva of *Cosmophila* and *Sylepta*, the newly hatched caterpillar feeds on the under surface of the leaf, leaving the upper membrane. In the succeeding instars, however, the larvae begin to roll the leaf and consume the whole tissue.

The newly hatched larva is pale yellow with the head and thorax dark in color. As the larva grows the dark color of the head and of the dorsal portion of the prothorax is shiny black. A full grown larva measures 2.5 centimeters long and .3 centimeter wide.

The pupa.—The pupa is 7 to 10 millimeters long and from 2 to 3.5 millimeters wide and reddish brown. The dorsal surface of the abdominal segments, are furnished with minute spines arranged across the segments in two rows, the anterior rows being more developed than the posterior ones. The cremaster is also provided with bristles but are distinctly shorter than those of the pupae of *Cosmophila* and *Sylepta*. The bristles are likewise curved or rolled at the end.

The adult.—The adults are brownish-yellow. The male is much smaller than the female being only about 8 millimeters long while the female is 12 millimeters. The male has a prominent "costal fold" of scales at the base of the front or costal margin of the forewing. The wing patterns in both sexes are similar.

Control.—Essentially the same control measures given for *Sylepta* are suggested. Collecting the eggs clusters is also practical.

Hymenopterous parasites have also been reared from the larvæ of *Sylepta* and *Homona* treated in this paper. These are of help in the control of the pest.

Liberations of *Trichogramma minutum* have been made in the field and the parasites have been reared from egg clusters of *Homona* sp., showing that this introduced parasite shows promise of getting established here.

THE PINK BOLLWORM (PECTINOPHORA GOSSYPIELLA Saund.) Plate 3, figs. 5 to 7.

This caterpillar, which is pink in color, (hence, the name) is undoubtedly one of the pests which is capable of serious damage when cotton is grown extensively and should be looked out for closely. It has been reported quite destructive in La Union.

In other countries, as in Brazil, Egypt and Mexico it is known to be the worst pest of cotton, the losses in yield of both lint and seeds being unusually heavy, running to millions of dollars. In the United States, the insect threatens to get established in the cotton belt and the United States spends hundreds of thousands of dollars every year for quarantine and eradication work. Wardle (1929) states that it disputes with the boll weevil (*Anthonomus grandis*) in America, the distinction of being the most important cotton pest in the world.

The adult moth is about 7 millimeters long from the tip of the head to that of the abdomen and 9 millimeters long from the tip of the head to that of either wing when the insect is at rest. The color is somewhat dark brown, with the patches on the forewings, being dusky dark. The forewings are fringed with hairs along the apical margin while the hind wings are fringed both along the apical and anal margins.

The caterpillar is about 1.2 centimeters long and 2.5 millimeter wide when full grown. It is conspicuously pink and the segments are all provided with weak pale yellow hairs or setae. The pupa is reddish brown, about 9 millimeters long and 3.8 millimeters in diameter. It is somewhat densely covered with setae, those at the anal end being distinctly larger and are hooked at the end.

The eggs have not been encountered in this work but according to Hunter (1918) they are laid singly or in small groups on the green bolls or in the flowers. Generally, according to the same authority, the eggs are to be found near the points of the green bolls in the sutures making the locks and as many as 20 eggs have been found on a single boll. The total number of eggs laid by a female was estimated to be about a hundred, the eggs, hatching in from 4 to 12 days. The larval stage during the summer in the United States, according to Hunter, occupies from 20 to 30 days. He cites Gough, in Egypt, as having found that the larvae would remain in a quiescent condition for over two years. He also mentions Busck, who found out that bales of cotton in which were placed infested seeds continued to reveal the presence of live larvae up to 18 months after baling. This ability of the larva to prolong its life as such has made possible the spread of the insect to many countries. The pupal stage, according to Hunter lasts from 10 to 20 days. In the Entomology Laboratory at Singalong, Manila, our record of the pupal period of the insect in November, 1934, is 11 days.

The moths do not live live long, the great majority of them according to Busck's records, dying in confinement in from 14 to 20 days.

Control.—The early matured bolls should be carefully examined for the presence of the caterpillars and all the infested ones should be gathered and fumigated with either carbon bisuiphide or sterilized with heat.

All the cotton seeds should also be fumigated and stored in tightly closed containers. They should be examined regularly for the presence of the pest.

After the harvest, old plants and fallen bolls should be destroyed. All volunteer and useless plants in which the insects may breed prior to the regular crop, and which thus may be the source of infestations to the latter, should be destroyed.

As to the use of natural enemies, Wardle (1929) says that there is really no effective parasite among the numerous ones which have been recorded, such as *Pimpla roborator* in Egypt or *Mirobracon mellitor* in Hawaii. He also says that there would seem to be possibilities among the parasites of the insect in African localities, or among the parasites of the allied species of *Pectinophora*. He adds that an egg parasite, owing to the exposed situation of the eggs, should offer the greatest possibil-

ity. In view of this suggestion, *Trichogramma minutum* (introduced by Dr. G. Merino) now being reared in our laboratory will be tried.

OTHER CATERPILLARS THAT ATTACK COTTON BOLLS

The corn ear worm, *Chloridea* (*Heliothis*) *obsoleta*, which is cosmopolitan, has also been found to attack cotton bolls, but the infestation at Singalong has been found very negligible. Baltazar (1934) states, however, that the caterpillars are a serious pest in the Ilocos provinces, feeding not only on the bolls but also on the flowers and squares, although it is quite possible that other species are involved.

Another caterpillar which has been observed at Singalong is that of *Earias* sp. (most likely *fabia*). The moth is light pink and has a triangular green area on each forewing. There is also a green patch on the dorsal portion of the thorax. The length is a little over a centimeter from the tip of the head to those of the wings when the moth is at rest. The larvae of the species of this genus attacking cotton are known to bore through the stems of the plants.

Handipicking of infested bolls, dusting with poisons and the employment of egg parasites in particular are suggested as control measures.

COTTON LEAF MINER (LITHOCOLLETIS TRIARCHA (Meyrick).[1] Plate 3, fig. 8 and Plate 4 fig. 1.

This has been found rather abundant in Singalong. As the name suggests, the flattened larvae feeds inside the leaves causing blotches or mines which later dry up. Two parasites of this leaf miner have been identified as *Elasmus* sp., near *homonae* Ferr., and *Sympiesis* sp. by Mr. Gahan of the U. S. Bureau of Entomology, which identifications were sent to us by Mr. Cushman of the same institution.

The collection of infested leaves and placing these in wire cages which will allow the parasites to escape and continue their beneficial work but will prevent the escape of the moths is suggested to minimize the attack.

COTTON STEM WEEVIL. Plate 1, figs. 2 and 3.

The larva of a weevil has also been observed to mine within the stems of cotton, causing them to produce swellings or gall-like formations. The plants are stunted and may succumb if

[1] Identified by Mr. Busck, of the U. S. Bureau of Entomology, from specimens taken to the United States by Dr. Merino in 1931, together with specimens of its parasites.

the injury be severe. The adult insect is about 3 millimeters, long, dark gray, and is apparently similar (if not identical) to another (*Phylaitis* sp.) found in India, which is figured in Indian Insect Life (1909) by Lefroy, to which reference Mr. G. C. Bellosillo, of the Bureau of Science, called the senior author's attention.

SUCKING INSECTS AFFECTING COTTON

A number of sucking insects attack cotton, the most important being the common mealy bug (*Ferrisia virgata* Ckll.), the melon aphis (*Aphis gossypii*) and the leaf hopper (*Empoasca flavescens* Fabr.) Besides the mechanical injury done by these insects, and the loss of sap from the host plants, they also exude honeydew, which serves as a medium for the growth of sooty mold, and this interferes with the food-making function (photosynthesis) of the chlorophyll. Then there is the possibility that at least some of these sucking insects may serve as carriers or vectors for the causal organisms or pathogenes of such local diseases affecting cotton or that the punctures caused may facilitate the entrance of such pathogenes. The general effect of all these injuries, together with that of certain other associated causes, is the stunting of the plants. These plants then produce very few or no boll and thus become virtually useless, even if they do not die immediately.

The combined mechanical injury alone by these sucking insects when abundant, to say nothing of the loss of substance on the part of the hosts, must be considerable, to say the least. In this connection published studies in the United States, such as those of King and Cook (1932) on the nature of the injury done to cotton by certain sucking insects are illuminating and may help all concerned in understanding similar injury caused by the local species of sucking insects. The summary of the work of these authors, is worth quoting:

> Experiments were begun in 1927 and carried through three years, at Tallulah, La., for the purpose of studying the lesions produced in stems and petioles by the cotton flea hopper and other plant-sucking insects. The object was to determine, if possible, whether the injury to cotton following the feeding of these insects was the result of a transmissible virus or due to mechanical or chemical injury.
>
> External indications of injury seemed to prove that only a part of the many insects tested had affected the plants in the way considered charac-

teristic of hopper injury, but later examination by microtome sections through the feeding points showed that practically all punctures resulted in the same type of internal injury. The swelling and breaking open of the lesions in some cases seemed to be the result of more extensive injury rather than injury of another kind.

The size of the lesions produced by one individual in consecutive feedings was often fairly uniform, but the toxicity of different individuals was decidedly variable.

The early reaction of the internal tissues of the plant is recognizable as an enlargement of nuclei and cells at some point along the feedings puncture. This has been observed in material preserved for sectioning 24 hours after the feeding. Dividing nuclei occasionally found in the preparations show that cell division is stimulated, and in this respect the lesions are comparable to the reaction of the plant to wound stimuli. The milder lesions may show only evidence of cell activity and more or less cell distortion, whereas in more severe forms areas of broken-down tissue develop. The full development of the lesion is rapid; and the external swellings, when produced at all, are usually visible by the second or third day.

Individuals of 10 species (7 Hemiptera and 3 Homoptera) were included in the tests. The average severity of the damage by different species was variable. Of the two more important field pests, the percentage of split lesions was 32.6 for *Lygus pratensis* and 9.5 for *Psallus seriatus*. About 7 per cent of the lesions caused by *P. seriatus* and 10 per cent of those caused by *L. pratensis* did not show externally. *Poeciloscytus basalis*, a species which is seldom taken on cotton, caused external swellings at every feeding point and produced the highest percentage of split lesions (58.2) of any of the species tested. Of all the individuals that fed more than once only two failed to produce the injury at some feeding point.

The feeding punctures of the three species of Homoptera used in the tests can be traced through the tissues by a well-defined "sheath" which stains a bright red with safranin. This may be found in sections made immediately after the feeding of the insects and is similar in appearance to the sheaths which have been described in aphid punctures. As in the case of the aphids, the paths usually end in the vascular tissue.

No sheath material was found about the punctures made by mirids, and the path taken by the proboscis of the species on which observations were made could not be definitely traced. At the most, in plant material preserved for sectioning soon after the feedings, a few ruptured cells have been found.

The experiments with the 10 species of plant-sucking insects, some of which do not feed naturally on cotton, have shown that nearly all individuals cause a reaction in the tissues of cotton stems and leaf petioles similar to that produced by the cotton flea hopper, *Psallus seriatus*. This is taken to indicate that hopper damage is due to injected substances normally present in the insects and toxic to the plant, rather than to a transmissible disease.

THE COMMON MEALY BUG (FERRISIA VIRGATA Ckll.) Plate 5, figs. 1 and 2; see also Plate 9, fig. 1.

The mealy bug, *Ferrisia* (*Pseudococcus*) *virgata* Ckll., has been observed rather serious to cotton at Singalong, Manila, and in other places, during the dry season. These insects are very prolific and in a relatively short time they practically cover the stems. They also attack the leaves.

This is undoubtedly the most common mealy bug in the Philippines and has a long list of host plants. Among other hosts, besides cotton, are eggplant, tomato, mango (*Mangifera indica*) different kinds of "San Francisco" (*Codiaeum* sp.), anona and guayabano, (*Anona* spp.) casoy (*Anacardium occidentale*) compea (*Vigna* sp.) cabbage, pechay (*Brassica* spp.) upon (*Lagenaria* sp.), patola (*Luffa* sp.), citrus, guava (*Psidium guajaba*) and gumamela (*Hibiscus* sp.). Among its recorded wild or semi-wild host plants are madre de cacao (*Gliricidia sepium*), ipil-ipil (*Leucaena glauca*) and macahia (*Mimosa pudica*). This species also occurs in other countries, such as Hawaii, Jamaica, Java, etc.

Superficially, it can be distinguished from other local mealy bugs by its having two prominent or conspicuous tail-like waxy fringes at the posterior or hind end of its body. Besides the powdery secretion covering especially the upper surface of its body the insect also has numerous glassy threads or filaments with which the newly born young are concealed. The mature female is from 4 to 5.5 millimeters long. Examined under the microscope, the antennae are 8-segmented and the tarsal claws are without teeth or denticles. These and other peculiar characters led Fullaway (1923) to place it under a separate genus, *Ferrisia* in honor of Dr. G. F. Ferris of Standford University, who (1919) made a careful study of its microscopic morphological characters. The new genus apparently has been accepted by other workers, among them being Takahashi (1924) who also records *Ferrisia virgata* in Formosa. For the microscopic characters of the species, one may also refer to Morrison's paper (1920).

Although this mealy bug has many enemies, three kinds of parasites having been reared in the course of this work and that it is also preyed upon by lady beetles (among them being the common lady-bird beetle (*Chilomenes sexmaculata*), and a species of *Scymnus* and aphis lions and the bug, *Geocoris tricolor*, it usually gains the upper hand during the dry season and causes

considerable harm. The insect becomes full grown in about a month and begins to produce many youngs a few days thereafter.

Colonies of this mealy bug are attended by several species of ants, among them being the common red ground ant, *Solenopsis geminata.*

THE MELON APHID (APHIS GOSSYPII). Plate 6, fig. 1; see also Plate 9, fig. 2.

The melon aphid (*Aphis gossypii*) vies with the mealy bug (*Ferrisia virgata*) in destructiveness. It has been observed that they attack cotton very early and retard their growth. At Singalong, Manila, cotton plants two weeks old planted in October, 1934, were found badly infested by this species.

This insect is cosmopolitan and is very variable in color as well as in size. As is true with other plant lice, both winged and wingless mothers are present and both reproduce parthenogenetically, that is without previous fertilization as is apparently true in the case of aphids in tropical and other warm climates, and of greenhouse aphids in temperate climates, as has been previously observed by Uichanco (1921 and 1924). The following partial statement by Patch, given by Wall (1933) on the variability of *Aphis gossypii* is hereby quoted (those in parentheses are ours):

> The colonies of the melon aphid present a motley appearance when these insects are crowded together on the underside of a leaf. Among the wingless viviparous females (the females that bring forth young actively alive) the colors may range from pale green to greenish black, or from nearly white to lemon yellow . . .
>
> In size the species varies as much as it does in color, and there are thus two reasons why the species has been named and renamed. Individuals of different sizes and colors and on different plants would be easily mistaken for different species . . .

On bearing cotton plants that were somewhat heavily infested, at Singalong, Manila, both in the field and in the greenhouse in November, 1934, most of the insects were lemon yellow in color and some were dull yellow with a greenish tinge and the adult insects were about a millimeter long and even somewhat less. In this connection the findings of Wall at St. Paul, Minnesotta are worth quoting (those in parenthesis are ours):

> In the greenhouse as long as the infestations on cucumber vines have remained sparse, the dark and intermediate colors have predominated among the apterae (without wings), the light colored individuals being exceedingly scarce. Repeated fumigation or spray control will hold a population to a very low figure and it is under such circumstances that

the complexion of the colonies will remain generally dark. On the other hand, either in the field or under glass, the light forms become very numerous, as a rule, when a condition of heavy infestation was reached . . .

Wall has also found that the darker forms (dark green, dusky yellowish green, dusky dull green) werein general bigger than the light colored individuals (pale white, lemon yellow and lighter shades of green).

The melon aphid has also been observed locally abundant on eggplants, melons, upo, cucumber and pechay and other cruciferous plants. Lady beetles, particularly *Chilomenes sex-maculata* (Plate 10, fig. 6) syrphid flies, aphis lion and a certain hymenopterous parasite, apparently of the family Aphelinidae, have been found to prey on it. Parasitized aphids are black and thus can be easily distinguished from the live ones, which are mostly yellow in color.

Colonies of this aphid are also attended by the red ant (*Selenopsis geminata*) and other ants. Colonies of the red ant in particular should be destroyed, preferably with the use of poisonous substances such as calcium cyanide and poisoned syrups, as they encourage the multiplication of the aphids.

LEAF HOPPERS (EMPOASCA FLAVESCENS Fabr.) [1]**. Plate 7, fig. 1; see also Plate 9, fig. 3.**

The most common leaf hopper on cotton is a small green species (*Empoasca flavescens* Fabr.), measuring about 3 millimeters in length. Like the melon aphid and the common mealy bug (*Ferrisia virgata*), they become very numerous towards the end of the rainy season and cause serious harm to the cotton crop. In 1926, the senior author observed that this leaf-hopper and the melon aphid and mites were chiefly responsible for the failure of an extensive cotton planting at Novaliches, Rizal.

The female deposits her eggs in the midribs of the cotton plants causing the injured spots to swell. Both the adults and the young are voracious feeders causing the leaves to wrinkle or curl up. They also attack eggplants and potatoes.

THE COTTON STAINERS (VACAVACAHAN) (DYSDERCUS spp.)

The farmers are very familiar with these insects so that they hardly need any description here. The species most common on cotton is *Dysdercus megalopygus* (Plate 8, fig. 1).

[1] This identification and that of **Machaerota ensifera** Burn., were verified by Doctor Merino.

The adults and the young or nymphs attack especially the cotton bolls. The eggs are laid in the soil, hence they are seldom seen.

The insects have many other host plants both wild and cultivated, giving preference to those of the family Malvaceae to which cotton belongs.

THRIPS. Plate 8, fig. 2 and Plate 9, fig. 5.

Two species have been observed on cotton causing the leaves to appear spotted or whitish. One of these—the bigger species—is a black one about a millimeter long and the wings are black and white. The smaller one is pale yellow and is the more common in the field.

The onion thrips (*Thrips tabaci*) is also recorded on cotton but we are not certain as yet as to the identity of this and the pale yellow one just mentioned here.

A black bug about 4 millimeters long and which may be mistaken for an ant has been observed to prey on the thrips.

RED SPIDERS OR MITES.

A red spider (*Tetranychus* sp.) has been observed abundant on cotton especially during the dry season. The nature of their injury resembles that of thrips. This red spider has also been found to attack beans and peas.

WHITE FLY (BEMISIA sp.). Plate 6, fig. 2; also Plate 9, fig. 4.

This white fly, which commonly attacks cabbage, also attacks cotton. Under greenhouse conditions, it has been found very harmful, attacking not only cotton and cabbage, but also cauliflower, tobacco, tomato and pechay. It has also been observed on roses and on certain other ornamental plants.

The adult insect is about a millimeter long and the body is yellow with its wings snow white and opaque. The eggs are laid in groups on the lower surface of the host plants. The characters of the pupal case and the adult conform to those given by Quaintance (1914) for the genus *Bemisia*. The insect closely resembles *Bemisia gossypiperda* M. and L., also a cotton pest in Sudia (Husain and Trehan, 1933). The nymps and pupae are preyed upon by a hymenopterous parasite and a ladybird beetle.

CERCOPID.

A species of Cercopid, *Machaerota ensifera* Burm., has also been observed on cotton. This feeds chiefly on the tender parts

of the stems of cotton. It is not usually abundant, however, and may be considered a minor pest. The insect is about 5 millimeters long, yellowish brown and has its scutellum produced into a spine which is directed backward.

CONTROL MEASURES FOR THE SUCKING INSECTS ON COTTON

The cotton planter should make efforts to control initial infestations. The mealy bugs and the aphids, especially, are at first localized. Soon after germination, the plants are usually attacked by these pests and the planter should go over the field often and examine the plants and initial colonies of these insects should be destroyed. Even crushing them with the fingers will help. They can best be destroyed, however, by spraying. It pays to have a good spraying equipment on hand, if one is to properly protect his crop from insect pests as well as diseases, if these be present. The following formula for destroying aphids as well as certain other sucking insects on cotton, (the thrips, white flies, the leaf hoppers) and the mites, dealt with in this paper, is suggested:

> Soft yellow, laundry soap—5 to 10 grams per liter of water or approximately $\frac{1}{10}$ to $\frac{2}{10}$ of a kilo in one petroleum-canful of water.

For the mealy bugs and the stainers a stronger solution is necessary to insure killing them. The amount of soft, yellow laundry soap should be doubled, that is, 10 to 20 grams per liter of water or approximately $\frac{1}{5}$ to $\frac{2}{5}$ of a kilo for every petroleum canful of water. The amount of soap may be increased.

Powdered soap, which is especially convenient for combating insects, is now in the market. It dissolves easily by vigorous stirring for a few minutes. This costs about ₱2.60 per 5 gallon can or about 12 kilos. Ten to thirty spoonfuls (levelful) for every petroleum canful of water have been found sufficient for killing plant lice, mealy bugs and other insects, like thrips, white flies and their larvae, and the cotton stainer. Mites also are killed by the soap solution.

If desired, tobacco infusion may be employed instead of pure water with the soap. For preparing this, tobacco stems, midribs, and other tobacco refuse may be employed. Enough of these are soaked in water in barrels or petroleum cans overnight. Strain before using to get rid of any tobacco parts which might clog up the nozzles of the spray pump.

In spraying against aphids, mealy bugs, and leaf hoppers, in particular, direct the spray to the under side of the leaves to be sure the insects are thoroughly moistened with the solution.

OTHER INSECTS ON COTTON

The following sucking insects have also been observed in this work on cotton but were very few and may be considered of minor importance:

Sucking insects:
- *Dysdercus poecilus* H. S.
- *Tectocoris lineola*
- *Saissetia hemisphaerica* (Plate 7, fig. 2)
- *Nezara viridula*
- *Drosicha townsendi*
- *Ricania speculum*
- *Dictyoprara* sp.

Biting insects:
- *Phaneroptera furcifera* Stal.
- *Prodenia litura*

The following are mentioned by Baltazar (1934) but have not been personally observed by us:

Sucking insects:
- *Helopeltis* spp., said to be serious at the College of Agriculture, Los Baños.
- *Antilochus nigripes.* (Specimens were collected by Mr. Toquero of our Division from cotton in Ilocos Norte in 1931.)

Biting insects:
- *Euproctis varians*
- *Acontia intersepta*

Dammerman (1929), in his book, "The Agricultural Zoölogy of the Malay Archipelago," gives the following insects as feeding on cotton among other host plants and they are listed here for some of them at least, occur in the Philippines:

Zeuzera coffeae Nieth. The red coffee borer, the adult being a moth.

Earias fabia Stoll and *Earias Insulana* Boisd., both noctuids. The caterpillars are boll feeders. Both are recorded in the Philippines and our specimens of *Earias* are probably of the former species but this has to be verified.

Collyris bonelli—a tiger beetle.

Aelopus (*Epacromia*) *tamulus* F.—a grasshopper. Recorded.

Glyphodes indica Saund—a pyralid moth. The caterpillars attack cucurbitaceous plants in the Philippines.

Euproctes (*Porthesia*) *scintillans* Wlk.—a lymantrid caterpillar said to be a serious pest of castor plant in the Malay Peninsula.

Nisotra gemella Erichs.—A flea beetle 2.5 to 3.5 millimeters long. According to Reveche (1922), this insect feeds on okra, roselle, gumamela, culotculotan, etc., but apparently he had not observed it on cotton.

Hypomeces squamosus F.—a weevil (Curculionidae).

Mylabris postulata Thunb.—a Cantharid (Meloidae). The larvae are well known predators of locust eggs but the adults feed on the pollen of flowers, including those of cotton.

Oxycarenus lugubris Match., of the family Lygaeidae; commonly known as the black cotton bug; 3.5 to 4 millimeters long with the forewings yellowish white, the central part being brown. The insects suck the juices of the seeds. This is listed by Woodworth (1921).

Dacus ferrugineus F. This is the mango fruit fly, the insect having been noticed in cotton bolls.

Lecanium (*Saissetia*) *nigrum* Nietn., a scale insect.

Pinnasphis aspidistriae Sign., a scale insect.

Pseudococcus citri Risso—a mealy bug, closely resembling *Pseudococcus lilacinus*, which is quite common in the Philippines.

Tetranychus coffeae Nietn. (*bioculatus* W. M.), the red tea mite.

The following are also listed by Woodworth (1921) as feeding on cotton but have not been observed by us:

Hypolimnas masippus Linn., a nymphalid.

Hippotion celerio Linn., a sphinx moth.

Euxoa segetis Chiff., a noctuid.

Oxycarenus hyalinipennis Costa, a bug (Lygaeidae).

Scale insects:

Hemichionaspis townsendi Ckll.

Pseudococcus filamentosus Ckll.

Saissetia nigra Nietn. (listed by Dammerman as *Lecanium* (*Saissetia*) *nigrum* Nietn.

Woodworth also lists *Homona menciana* Walk. We are not certain as yet whether this is the same as the species we have found on cotton.

In addition to these records, the following item from Espino (1915) about cotton pests reported by a Spanish investigator prior to American Occupation is of interest:

> The insect enemies of cotton reported during the Spanish regime in these Islands are 'grillo de los campos' (cricket), la oruga gris de una mariposa (Noctua subterranea) and "larva del Melolontha vulgaris."

The *Noctua subterranea*, as quoted by Espino, may be either one of the common noctuids, *Prodenia litura* or *Chloridea* (*Heliothis*) *obsoleta*, which attack cotton, and larvae of which pupate in the soli. *Melolontha vulgaris* is a European species and is not recorded in the Philippines. It is most likely that the larva

involved was that of the "toy-beetle," *Leucopholis irrorata* Chevr., the most destructive grubs here and attacks the roots of many crops (Otanes, 1931) including possibly cotton. Should these and other grubs be found abundant on lands that are being prepared for cotton, they should be collected and killed. Certain other control measures, such as collecting the beetles and spraying their favorite food plants may be employed.

SUMMARY

In this survey an attempt has been made to bring together all the insects and other allied organisms that are known so far to feed on cotton in the Philippines. The species given by Dammerman in his book "The Agricultural Zoölogy of the Malay Archipelago" as feeding on cotton are included, for they are found in the Philippines although some of them have not been locally observed or recorded as yet to feed on cotton, so far as we have ascertained. Two of these are the red coffee borer, *Zeuzera coffeae* and the mango fruit fly, *Dacus ferrugineus*.

Additional life history data and other observations given for the cotton boll weevil, *Amorphoidea lata* Motsch. are given. Similar local observations on other important cotton pests, namely, on three leaf-feeding caterpillars, *Cosmophila erosa* Hubn., *Sylepta derogata* Hubn., *Homona* sp., and on the pink bollworm, *Pectinophora gossypiella* Saund. and the common mealy bug *Ferrisia virgata* Ckll., are also being presented for the first time.

The following are apparently new local records of insects attacking cotton:

1. A weevil, the larvae of which mine or bore within the cotton stems. It is apparently closely related to a cotton pest in India, figured by Maxwell-Lefroy and Howlett, as *Phylaitis* sp.[1]
2. An aleyrodid, *Bemisia* sp.
3. At least two kinds of thrips.
4. *Machaerota ensifera*, a cercopid.
5. A bollworm *Earias* sp.—most likely *fabia*. Caterpillars of the genus *Earias* are serious pests of cotton in other countries.
6. A cotton leaf miner, *Lithocolletis triarcha*.

[1] A lepidopterous stem borer has also been reported from Hacienda Luisita, Tarlac (see plate 4, fig. 2). The insect proved to be the same as the one reared at Singalong and dealt with in this paper as *Earias* sp. (F.Q.O.)

Based on this preliminary survey, the cotton boll weevil (*Amorphoidea lata*), the pink bollworm (*Pectinophora gossypiella*) and the other caterpillars attacking the bolls, *Chloridea obsoleta* and *Earias* sp. are among the most important biting insect pests of cotton here. The most serious sucking insects are the common mealy bug, *Ferrisia virgata*, the melon aphid, *Aphis gossypii*, and the jassid, *Empoasca flavescens*. The last two, together with red spiders, were chiefly responsible for the failure of an extensive cotton planting in Novaliches, Rizal, in 1926.

The leaf eating caterpillars, *Cosmophila erosa*, *Sylepta derogata*, *Homona* sp. and the leaf miner, *Lithocolletis triarcha* are also capable of serious damage when abundant. Because of its habits, the stem borers should be considered as an important cotton pest—more important even than some of the bollworms.

Certain local natural enemies of the important cotton pests are recorded.

Prompt control of initial infestations of any one of the most important cotton insects is urged, considering the income per hectare of cotton compared with certain other crops, is much less and the small farmer therefore can hardly afford to employ insecticides. The value of vigilance and of mechanical methods of control, such as handpicking for controlling certain pests, at least, such as the adult boll weevils, leaf eating caterpillars, should not be underestimated.

Attention is also called to the proper culture of cotton so as to produce vigorous and hardy plants, and in this way at least minimize expenses for controlling insect pests as well as diseases. In this connection, attention to the water requirement of the cotton plant is stressed. Attention is also called to the so-called "water balance of plants" and "water duty practice" in connection with insect infestations.

Attention is likewise called to the possibilities of employing the newly introduced *Trichogramma minutum*, especially in connection with the control of the lepidopterous pests, the bollworms in particular. This species shows indication of becoming established here, having been already reared from Tortricid eggs where liberations have been made.

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ILLUSTRATIONS

Plate 1

Fig. 1. The cotton boll weevil (*Amorphoidea lata* Motsch.) showing larvæ, pupae and adults.
2. The cotton stem weevil (related to *Phylaitis* sp. in India).
3. Portions of cotton stems showing injury by larvae of the cotton stem weevil.

Plate 2

Fig. 1. The "Abuliton moth" (*Cosmophila erosa* Hubn.) showing adult moths, larvae and pupae, parasitized caterpillar and parasites (see also Plate 10 for the parasites, enlarged).
2. The pyralid cotton leaf folder (*Sylepta derogata* Fabr.) showing an adult moth, caterpillars and pupae.
3. Caterpillars of (*Cosmophila erosa*) on cotton leaves showing nature of damage.
4. Tortricid leaf roller (*Homona* sp.) showing female and male moths, caterpillars and pupae.

Plate 3

Fig. 1. Egg of cotton boll weevil (*Amosphoidea lata*). Enlarged, ×20.
2. Egg of *Cosmophila erosa*, ×28.
3. Egg of *Sylepta derogata*, ×19.
4. Egg mass of the Tortricid leaf roller, *Homona* sp., ×1.6.
5. 6 and 7, caterpillar, pupa and adult, respectively, of the pink boll worm (*Pectinophora gossypiella*), ×5, ×5, ×3, respectively.
8. Adult of the cotton leaf miner (*Lithocolletis triarcha*) Meyrick, ×20.

Plate 4

Fig. 1. Cotton leaves showing injury by the cotton leaf miner, indicated by arrows.
2. Portions of cotton stems showing injury by a lepidopterous insect. A caterpillar is shown by an arrow.

Plate 5

Fig. 1. A leaf and a portion of the stem of cotton showing mealy bug (*Ferrisia virgata* Ckll.) infestation. See also plate 8, fig. 1.
2. Cotton plants at Singalong, Manila, showing a heavy infestation by mealy bugs (*Ferrisia virgata*).

Plate 6

Fig. 1. Cotton leaves showing melon aphid (*Aphis gossypii*). See also Plate 9, fig. 2.
2. Cotton leaves showing larvae and pupae of the white fly (*Bemisia* sp.). Adults are also shown. See also Plate 9, fig. 4, which shows how the adult white flies look like.

PLATE 7

FIG. 1. A tree cotton showing nature of injury by the leaf hoppers, *Empoasca flavescens*. Note the curled up leaves. Aphids and mealy bugs were also found on the plant thus contributing to the injury.
2. Scale insects (*Saissetia hemisphaerica*).
3. Cotton leaves at left showing melon aphids, *Aphis gossypii*. Eggs (at A), larva and pupa (at B) and adults of ladybird beetle, *Chilomenes sexmaculata* (at C) which is predatory on the aphids, are shown.

PLATE 8

FIG. 1. The cotton stainer (*Dysdercus megalopygus*) and nymphs. A cotton boll showing effect of the punctures is likewise shown.
2. Normal cotton leaf at left. At right, a cotton leaf showing nature of injury by thrips. (The work of red spiders or mites resembles that of thrips.)

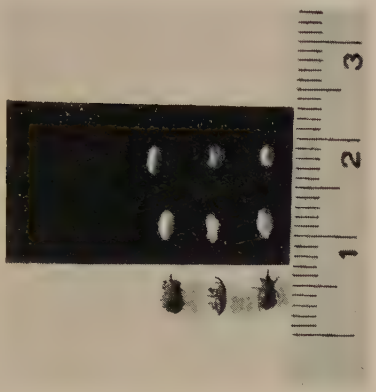
PLATE 9

FIG. 1. A mealy bug (*Ferrisia virgata*), enlarged, ×6.
2. A wingless female of melon aphis (*Aphis gossypii*), ×34.
3. A leaf hopper (*Empoasca flavescens*), enlarged, ×10.
4. White flies (*Bemisia* sp.), ×4.
5. One of the thrips on cotton, enlarged about ×40.
6. The egg parasite, *Trichogramma minutum*, introduced by Dr. Merino, ×73. (This introduced parasite has given indication of becoming established, having been reared from the eggs of *Homona* sp., and a nymphalid butterfly.)

PLATE 10

FIG. 1. A parasite (*Euplectrus* sp.) of the caterpillar of the "Abutilon Moth," enlarged, ×21.
2. A caterpillar of same moth showing eggs of the parasite, as indicated by arrows, ×6.
3. A parasitized caterpillar. The larvae of the parasites had moved underneath the caterpillar and had fastened the dead caterpillar to a leaf by means of their silken saliva, ×5.
4. A full grown larva of the parasite, ×13.
5. A bug (*Geocoris tricolor*), a predator of the adult cotton boll weevil (*Amorphoidea lata*) and certain other insects, ×4.
6. Adult ladybird beetle. (*Chilomenes sexmaculata*), a plant lice predator, ×4.
7. Another ladybird beetle, ×4.

(All photographs were taken by the Division of Publications, Department of Agriculture and Commerce and the drawings by the authors.)



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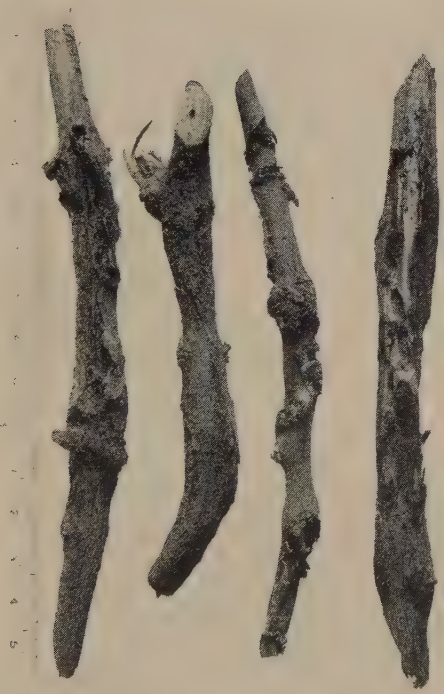

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PLATE 1.

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PLATE 2.

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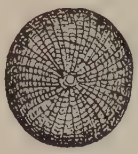

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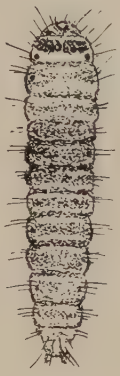

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PLATE 3.

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PLATE 4.

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PLATE 5.

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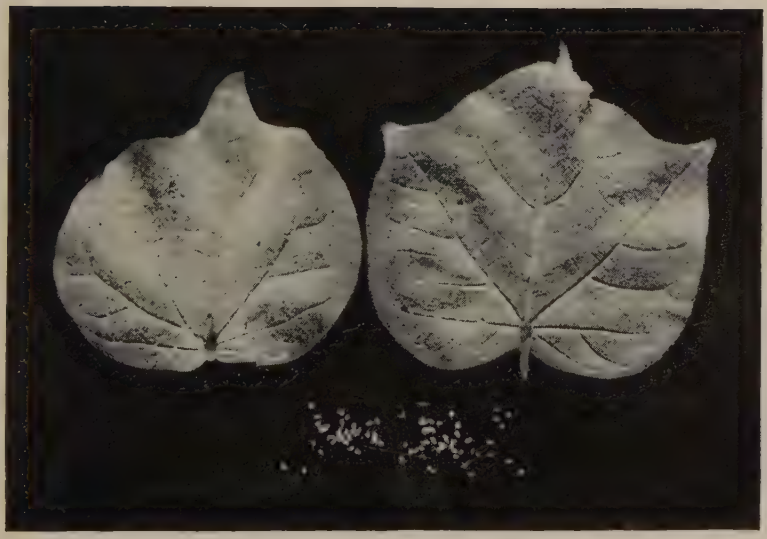

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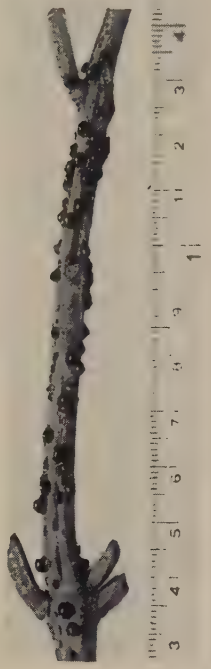

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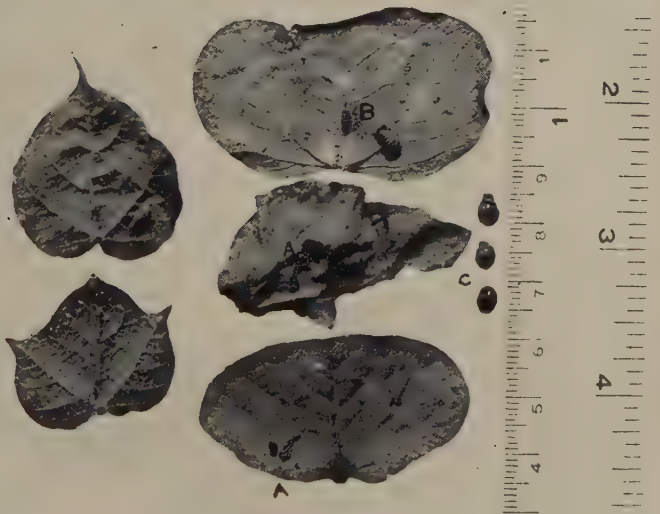

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PLATE 7.

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PLATE 8.

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PLATE 9.

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PLATE 10.

BERMUDA ONION [1] (*ALLIUM* CEPA)

By ANIANO ELAYDA
Assistant Agronomist, Bureau of Plant Industry

FIVE PLATES AND ONE TEXT FIGURE

The growing of Bermuda onions is a comparatively new industry in the Philippines, but it has taken hold and promises to be of considerable agricultural importance. Although the native small bulb onions ("sibuyas Tagalog") have been grown on a small scale for a number of years in many localities, particularly Batangas and the Ilocos provinces, it is only recently that we have been fairly successful in obtaining on a commercial scale good crops of the Bermuda onions.

The name "Bermuda" onion derives its name from the Bermuda Islands where it is largely grown for export to the United States. Seeds of this onion are imported from the Canary Islands which are situated on the northwest coast of Africa in latitude 28° North. The climate is subtropical. The Philippines is about 15° North latitude.

Statistics.—The importation of onion into the Philippines from the United States, Dutch East Indies, British East Indies, Australia, Egypt, China, and Japan, is given in Table 1.

TABLE 1.—*Importation of onions into the Philippines.*

Year	Quantity	Value
	Kg.	
1927	7,345,551	₱495,020
1928	10,528,529	695,373
1929	8,985,378	708,146
1930	9,463,319	542,407
1931	13,939,647	624,067
1932	12,059,183	527,281

Varieties of Bermuda onions.—Bermuda onions belong to the mild-flavored group. The three best known varieties are the Crystal Wax, the Yellow (often called the White Bermuda) and

[1] Bermuda onions are commonly called "sibuyas Bombay" in Tagalog.

the Red Bermuda. The Yellow Bermuda is the principal commercial variety. The Red and Yellow Bermuda varieties have already been tried with success in the Philippines and although they have more or less the same yielding quality the Red variety has many objectionable features as a commercial variety, such as brittle dry outer scales; a comparatively high number of splits and doubles; a low percentage of No. 1 onions; irregular shape; and an unpopular color. The Yellow variety is smooth and able to stand much more unfavorable weather conditions.

The Red and Yellow varieties are characterized by flat shape and mild flavor.

Soil, water, and climatic requirements.—The climate most suitable to the proper development of Bermuda onions is both mild and dry. In the Philippines active growth takes place between October and January, the period of mild weather. The planting must take place during this period so that the dry months from February to April may be utilized for maturing the crop.

The Bermuda onion is not suited for planting during the rainy season as it tends to develop vegetative growth at the expense of bulb formation, and rainy weather is not suitable for drying the bulbs, so that shipping and storing cannot be properly done. When the crop is grown under excessive rainfall or too much irrigation, the shipping or keeping quality do not properly develop.

It is very essential that the harvesting and curing be done during March, April, and the early part of May when there are no rains.

It has been observed that Bermuda onions will grow in any kind of soil as long as it is well drained and the moisture content adequate for a period of about two to three months after transplanting, with the only difference that on poor lands the bulbs will be smaller and harder and on rich land bigger and possibly softer, with poorer shipping quality.

An ideal soil for Bermuda onions must have adequate active plant food for ready assimilation, and be porous, mellow, friable, and well drained, but able to retain a proper quantity of moisture. Bad weeds must be absent. Provided the soil is fairly rich and of good texture the use of manure is not necessary in the Philippines as the bulbs have a tendency to grow too big, thick-necked, and to have poor keeping quality.

1. *Selection of land.*—In planting onions on a big scale, the following considerations must be made before selecting the land:

(*a*) Water supply for irrigation and cost of delivery.
(*b*) Risk in handling and marketing a big crop.
(*c*) Is the crop to be grown by dry farming or by irrigation methods?
(*d*) Weed control.
(*e*) Transportation facilities.
(*f*) Labor supply.

If the onions are to be grown under irrigation, the land and location should be chosen with reference to economical and convenient water supply; if they are to be grown without irrigation the land should be situated in an area where the soil is retentive of moisture during the active growing period.

Because of the heavy investment on seeds and labor, the large-scale producer should be certain of production and should foresee and avoid risks in handling and marketing the crop.

Onion farming needs a comparatively large amount of hand labor in planting and weeding, unless the land is free from bad weeds.

As to types of soil, preference should be given to low lying lands along river borders which are predominantly silty loam on account of occasional inundation. This soil is productive without irrigation, but if the water level is too low it requires irrigation to maintain sufficient moisture on the surface for the heavy crops. Alluvial surface soil and clay subsoil evenly admixed with fine gravel but with irrigation, is good soil for this crop. Red sandy soils and darker chocolate loams are good for quick-maturing crops. Places bordering the coasts which have usually dark sandy soils or light sandy soils are good. They are not sticky and can be easily worked.

And soil of the types described above will produce profitable crops under good farming practices.

2. *Preparation of land.*—The land for transplanting should be reduced to a good state of tilth before transplanting. The land should be prepared long before the time of transplanting. When planting time comes the land must be free of weeds, with very fine tilth on top, and compact below.

3. *Kinds of planting materials.*—Bermuda onions may be planted (*a*) by seed, (*b*) by sets, and (*c*) by seedlings.

(*a*) *By seed.*—After the field has been thoroughly prepared and the rows are made the seeds are drilled. The furrows are made shallow with a native plow or a marker. At least 90 grams of seed are sown per 100 meters of row and the seeds covered to a depth of about one centimeter. When home grown seed is not available, this item will be quite expensive. When the young plants have attained a height of about 10 centimeters or have become well established, they are thinned to 10 centimeters apart in the row. Direct planting is not to be recommended on land which is apt to be weedy, as the growth of weeds may choke the young plants and make weeding expensive.

(*b*) *By sets.*—By "sets" is meant small bulbs about one and one-half centimeters in diameter resulting from arrested growth. To produce sets the seeds are sown very thickly on rather poor soil at the rate of 7 to 8 grams per square meter. The young plants cannot develop bulbs fully, due to lack of space and limited moisture; consequently growth is arrested. The sets are harvested, cured, and kept in a cool dry place.

(*c*) *By seedling.*—About six to eight weeks before the young onion plants are transplanted in the field the seed is sown or drilled in the seed bed, whence the young seedlings are transplanted in the field. It is always desirable to transplant stocky seedlings. Stockiness may be induced by clipping back the tops in the seed bed whenever they reach a height of about 15 centimeters. The seedlings are set out in the field with the same distance of rows and of plants in the row as in planting by sets. The most economical way of raising Bermuda onions on a commercial scale is by seedling, known as the transplanting method.

4. *Propagation of seedling.*—Fresh stocks of onion seeds harvested about July in the Canary Islands arrive in the Philippines about September. The time of seed sowing in propagating beds is determined mainly by the prevailing local conditions of a particular region. When the crop is not to be grown under irrigation, the seeds sould be sown early during the September–October period, and if planted under irrigation, sowing as late as the November–December period may be advisable. A hectare of land will require about 3 kilos of seeds and this amount would require a sowing area of 150 to 200 square meters of space.

Friable loamy soil is preferable for seed beds. Heavy soil is objectionable and dangerous as it tends to crack during the germination period of the seeds. The soil should be reduced to a

state of very fine tilth long before sowing in order to remove all weeds. The soil may be sterilized by burning trash on it, restirring the soil and burning trash a second time to kill ants, other insects, and fungi that may be present in the soil. The land should be divided into beds about 120 centimeters wide and raised a few inches above the path. It would be well to allow all weed seeds to germinate before sowing the seeds, because, if the germinating seeds are invaded by weeds, it will be very difficult to weed the plot without destroying and disturbing the tender seedlings.

The seeds should be sown thinly and uniformly and covered with a layer of fine soil about one centimeter thick. After sowing it is necessary to give it a good watering with a spray watering can. The top soil should be kept moist, but if strong continuous rains occur, portable shade to protect it from drying out should be provided. The shed should be removed after the rain, otherwise shading is not necessary.

It is absolutely essential that the beds have the necessary frames and removable sheds in order that when rains come the seedlings can be protected. Afterwards the tender seedlings should be given light watering every day if necessary. Within a week the seeds start to germinate. Before the seeds germinate ants may do considerable damage by eating them. To prevent destruction by ants, powdered rice, corn, or grated coconut meat should be spread along the edges of each bed to attract the ants, and to keep them from destroying the onion seeds. After a month or so, if the soil is rich and is watered when necessary, the seedlings should be ready for transplanting.

The critical stage in the life of the young seedlings is when they are just coming out of the soil. Too much watering encourages growth of damping-off fungus, so that, once developed, this becomes fatal to the seedlings as no remedial measure is practicable. The seed bed should be watered only enough to keep the young plants grow evenly, vigorously and uninterruptedly. A steady, even growth, is very essential for a uniform crop of good onions. To stimulate the growth of seedlings, a dressing of 6 to 8 tablespoonfuls of ammonium sulphate dissolved in a petroleum-canful of water should be applied when the seedlings are two or three weeks old.

If the seedlings grow fast but are tender and slender, they should be clipped back to induce stockiness.

5. *Time of planting.*—Onions being a crop that requires plenty of moisture and warmth, the time to plant them is about the close of the rainy season; that is, during October to November for non-irrigated areas and December to January for places where irrigation is available. The moisture content of the soil should be adequate for at least two months after transplanting. At the time of transplanting the field must be moist and not dry, and if the soil is dry, irrigation must follow soon after transplanting. The beds should be watered at the time the seedlings are pulled up. The seedlings should be clipped 10 to 15 centimeters and should be carried in shaded baskets to the field and then planted as quickly as possible. The plants may wilt soon after transplanting, but as long as they are stocky they will keep on growing. Transplanting can be done any time of the day. But during the hottest part of the day the roots must be soaked in water before planting, as this helps them to recover speedily. Under this condition the seedlings can withstand hot weather.

6. *Depth of planting.*—The proper depth at which the seedlings should be set in the field is very important. Too deep planting is very objectionable as it retards bulbing or will make the bulbs elongated instead of flat or round. If the plants bulb at all when planted too deep, the bulbs are likely to rot, especially in the fields that retain too much water. It would be a good idea to start rather shallow planting, as in the course of cultivating the earth can be thrown toward the plants to cover the bulb region should this be necessary. Where soil remains moist under the surface, there will be no need of throwing the soil to the plants. From 2 to 3 centimeters is about the proper depth at which to set the seedlings. At any rate, covering the axils of the youngest leaves should be avoided. Planted at this depth, the onion bulbs before harvesting are almost on top of the ground before harvest time.

The depth of the furrow should depend upon the moisture content of the soil and the system of cultivation to be employed. If the soil is too moist, shallow or slightly raised furrows should be made, and if the surface soil dries up readily, the furrows should be made deeper.

7. *Method of planting and number of plants per hectare.*—There are different methods of planting to suit the area to be planted, the labor supply, and the irrigated or nonirrigated land; namely, the single-row system for animal cultivation, the bed-system, and the row-bed system for hand cultivation. The

single-row system of planting is carried on shallow or slightly raised ridges about 40 centimeters apart for the hand cultivator and 70 centimeters to 100 centimetres for the animal cultivator. The seedlings are spaced about 10–15 centimeters apart in the row.

The bed-system of planting consists of making a bed about 100–150 centimeters wide and about 10–20 centimeters above the path, the length depending upon the convenience of the planter. The height of the bed above the level of the path should depend upon the texture of the soil; that is, loose soil should have low beds, and heavier soil, higher beds. The path should be of convenient width to be comfortable either for weeding or watering. In planting on a large scale, watering may be done by allowing the water to flow between the beds and to seep through the bed. In this case the paths between beds should be made wider.

The double or treble-row or row-bed system has two or three rows drawn close together by a marker. The rows are 15 to 20 centimeters apart, leaving convenient spaces about 70 centimeters wide between extreme rows, for animal cultivation and for irrigation. This system allows the planting of more seedlings to economize cost of cultivation, irrigation, and weeding.

In growing onions under irrigation, if the row-bed system and animal-drawn cultivation is to be practiced, the rows should be shallow, so that in the course of cultivation the onion bulbs will not be buried too deep by the throw of earth towards the plants. It is sometimes advantageous to plant on low ridges to prevent too deep covering of the bulbs and at the same time drain off excess water.

The estimated number of bulbs and weight per hectare is shown in the following table:

System of planting	Distance	Number of bulbs less 12 per cent loss	Weight in kilos at 15 bulbs per kilo
Single row	40×10	220,000	14,666
Double row	70×10	220,000	14,666
Do	80×10	195,360	13,024
Treble row	80×10	264,000	17,600

8. *Cultivation.*—The field can be cultivated either by hand or with a fine-toothed cultivator drawn by an animal. Weeds

should never be allowed to gain a foothold, for the onions can never amount to anything if the land is allowed to grow weeds. Hand weeding should always be resorted to. Hand weeding being very tedious, the cleaner the land is made before planting being very tedious, the ileaner the land is made before planting the lower the weeding bill will be. Two or three thorough weedings are enough to check the growth of weeds.

Onions are very shallow feeders, so that the mass of roots grow near the surface of the soil. Hence, sallow cultivation should be done frequently to keep a soil mulch and avoid baking and cracking. After irrigating the field it is very essential to keep the surface soil stirred. Whether the planting is in single, double, or treble rows, the same principles apply; that is, cultivation is needed after irrigation to maintain uninterrupted growth. The soil should always be cultivated slightly toward the onion plants so as to keep them covered with a thin soil mulch. The bulbs should never be covered thickly during cultivation as that may induce rotting, especially if there is too much moisture in the soil.

9. *Fertilization or manuring.*—Soil of proper texture which may be either loamy inclined to be silty or sandy loam, and of average fertility, does not have to be manured, lest it produce onions which are too sappy and thick-necked and of poor keeping quality. Manure applied to soil where it is not needed will only make the soil very porous. However, clayey soil that hardens on top will grow onions when manured adequately so as to make the top soil friable when dry, provided it is well drained. Manure should be applied in quantities from 5 to 10 tons per hectare. It may be hauled to the field and spread as uniformly as possible on the surface and then plowed in afterwards.

On poor land the use of ammonium sulphate as a top dressing at the rate of about 150 kilos (20 per cent N) per hectare will be beneficial.

10. *Irrigation and watering.*—Water is the principal determining factor of success in the raising of profitable onion crops. In order to obtain a good crop of onions the soil region where the root system is distributed should be moist but never with standing water during the active development of the plants. This period continues for two months after transplanting.

The root system being shallow the plant has not the power to grow deeply to reach the moist layers of the soil; so that even rich soil with a deep moisture level would grow on unsuccessful

crop. Soil conditions favorable to corn, peanuts, or tobacco would suit onions well, provided soil moisture is ample.

In irrigating an onion field, two essential factors should be considered: (1) to keep the soil well supplied with moisture but not to allow standing water continuously, and (2) to cultivate, particularly after irrigation, as soon as the surface soil permits in order to conserve moisture and prevent cracking and baking. The frequency of applying water must be timed to produce economically a crop of good keeping quality. Improper application of water will destroy the keeping quality for the reason that too much water applied untimely will induce the plants to develop big-necked onions and retard the maturation of the crop. In the light of past observation, four to eight irrigations during the growing period of about seven to eight weeks after transplanting should be enough. After this period, the plants should have fully developed foliage with fair-sized bulbs. Toward the period of maturity little or no water is needed as there is danger of starting a new growth, but the surface must be kept well pulverized.

To irrigate, the water must be run in shallow furrows between the rows of onions or in paths between the beds and allowed to seep into the rows or through the beds. Undue flooding heaps the earth around the plants and buries the plants deeper than is desirable. To apply water uniformly the land must be level, and if the soil is porous, the rows or furrows and beds should not be unduly long.

11. *Maturing, harvesting, and curing Bermuda onions for the market.*

(*a*) *Maturing the crop.*—The first indication of ripening or maturity is in the condition of the necks of the plants. When the necks are shrivelled or softened and the tops have fallen, even though some of the tops may yet be green, the crop may be harvested. The entire crop may be harvested if about a third of the tops are down and most of those standing have softened necks. Owing to unevenness in the soil, some patches will drop earlier, others later. Hence, judgment must be exercised and the best average condition of the maturity of the crop determined. It is, however, preferable that the individual plants which have shown indication of maturity be harvested daily. When the onion begins to dry up gradually from the tips of the leaves down to the neck, and the neck remains rigid and firm,

an abnormal process of ripening si taking place. This condition makes for poor curing and keeping qualities. Onions maturing in this manner should be separated from the stock and marketed promptly during the harvesting period.

Maturing onion bulbs should never be permitted to start a second growth once they are well bulbed to fair commercial size, otherwise their curing or keeping qualities are ruined. Heavy rains and excessive irrigation may easily induce second growth in an onion crop already beginning to mature, so that irrigation should be done with great care after the bulbs have reached fair size.

(*b*) *Harvesting.*—Onions which have shrivelled or softened necks or fallen tops should be harvested. In harvesting, the onions should be dug or pulled off gently in order not to break the dry scales of the maturing bulbs. When onions are dug and clipped too green, or before they have been permitted to lie in the sun for a day or so to cure and dry, the bulbs may force out their central buds again as if starting a second growth. Bulbs which have started to grow for the second time should be culled and cured again. If the onions have fully matured and dried in the field, they should be clipped at once. These onions can be crated and marketed without further curing.

Green or moist onions should never be crated because they decay quickly. They should first be properly spread and dried before sorting, packing, and loading. The tops should be clipped to about one-half inch stubs. If the necks show much sap when clipped, the bulbs should by all means be left in the open to cure well at the stubs. This will insure better keeping qualities especially during warm humid days. Care must be taken during exceedingly bright sunny days that the onions are kept in the sun just a few hours and then brought to the curing shed out of the direct heat.

(*c*) *Curing.*—From the field after a day or two of exposure to sunshine, the onions should be hauled to a house or shed (a roofed shed open at the sides and ends) where they should be laid on racks made of wire or bamboo, preferably the latter, or else placed on a dry straw-covered floor. The bulbs should not be heaped. Care should be taken that the shed admits a good current of air. In a week or so the tops will be quite dry and the onions will have a tough dry skin on the outside which will protect the bulbs. The tops should be pulled off or cut with a knife if they are thick-necked. The bulbs are ready to pack

in crates for the market. In clipping or twisting the tops, a stub about two to three centimeters long should be left to avoid the exposure of the succulent tissue of the fleshy scales of the bulb. Care should be taken to avoid bruising the bulbs and thus opening the way for organisms which cause decay.

Another way of curing onions on a small scale is to plait the tops into a rope and hang up the bulbs in a dry airy cellar or roofed shed. The onions cured in this way may keep up to five or six months. When the onions are thoroughly cured and dried they may be shipped with safety.

(*d*) *Construction of the shed.*—The capacity or size of the shed should, of course, depend upon the size of the harvest expected from the planting.

The principal points to be considered in building a shed are (1) maximum ventilation, (2) safety of the bulbs from pressure due to heaping, and (3) ease in handling the onions. To obtain these, (1) all sides should be open, (2) shelves made of

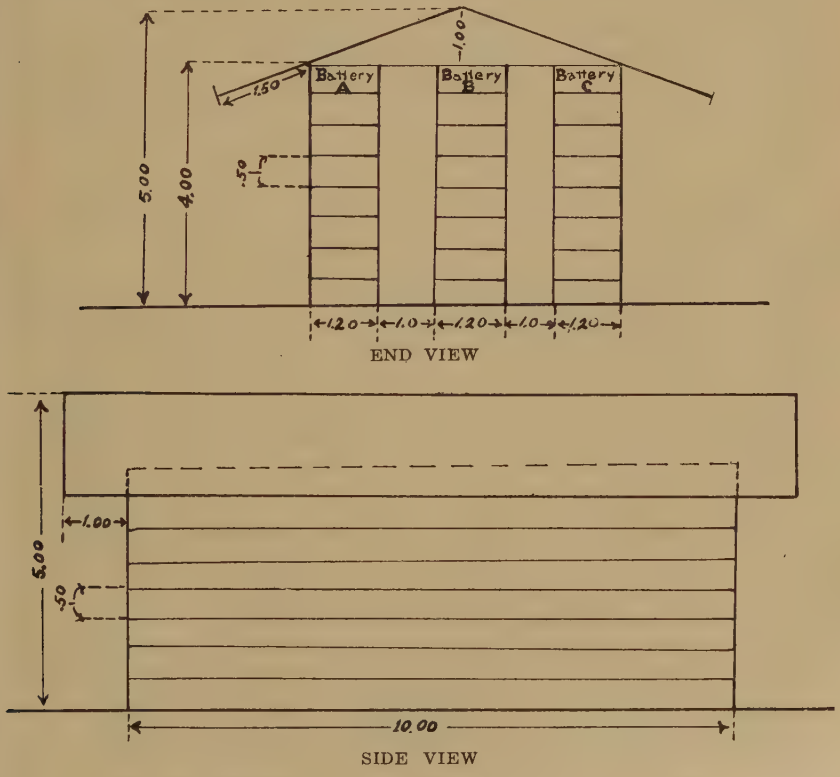

FIG. 1. Curing shed calculated to have a space of 864 sq. m. for drying. It will hold from 15,000 to 20,000 kilos of onion bulbs. Batteries A,B,C, are shelves 120 cm. wide running longitudinally along the shed with 50 cm. each way down and above the others.

either wire netting or split bamboo should be constructed, and (3) there should be aisles between the batteries of shelves from which the worker can reach the middle of these shelves. (Text fig. 1.)

ONION PESTS AND DISEASES

In Batangas regions growing small-bulb onions (sibuyas Tagalog), a certain malady locally known as "Pasik" is widespread. It is prevalent mostly during February. The soil planted to this crop is infested with this malady. Bermuda onions planted on fields that are infested or near the plantings of small bulb onions were observed to be infested with a similar malady.

The appearance of infested plants is very striking. Single plants or groups may be affected. The most characteristic development is in definite spots of irregular size and varying area in which the plants appear whitish and dry from a distance, owing to the absence of coloring matter in the leaves. A field with advanced infestation has the appearance of being partly burnt over. Where the plants partially recover, they remain dwarfed or stunted and bushy. Occasional plants may be found to remain healthy even in the midst of the most infested spots. This infestation described in general was caused principally by thrips (*Thrips tabaci*) and was found to be associated with many other troubles, as follows:

Leaf-mold (*Black stalk rot, Macrosporium parasiticum*).—Practically all the stalks or leaves broken off at girdled area with the free and dry portion near the ground still green were affected. Under moist conditions the disease produces black mold on the dead tissues of the leaves. The fungus attacks the leaves of onions independently or following a disease known as mildew. In the latter case, the damage is quite serious.

Mildew or blight (*Peronospora schleideni*).—The attack occasioned by this disease is quickly followed by the black stalk-rot and therefore cannot be recognized readily. Plants attacked by mildew and not overrun by black mold or black stalk-rot show the characteristic symptoms of the disease, which at first appears as a violet, furry covering on the outer surface of the leaves. At a later state the leaves become pale green and finally yellowish. Under this condition the dead leaves appear blighted, the growth of the plants is reduced, and as a consequence the bulbs remain small.

The spores of *Macrosporium* and *Peronospora* fungi causing leaf mold and mildew are easily carried by the wind to healthy plants and in damp weather drops of water on the plants furnish sufficient moisture for their development. This growth of the fungus penetrates the tissues of the plant and absorbs food from it, causing the leaves of the onion plants to shrivel and die. This fungus hibernates in the diseased leaves and soil and becomes active during the next planting season and again starts the disease in the new crop.

Bulb rot (*Fusarium zonatum*).—This disease is recognized by the characteristic yellowing and dying back of the leaves from the tips. When plants suffering from this kind of malady are pulled up the roots of those newly infected show weakness at the beginning of the rot, whereas the bulbs of those in an advanced stage of the disease show a semi-watery decay advancing from the base of the scale upward. Under this condition the bulbs are soft and slimy to the touch. The presence on the affected tissues of the bulbs of such other organisms as the nematodes and bacteria hasten the decay of the bulbs. Maggots may also be present in the decayed bulbs but they are known to cause only slight damage.

CONTROL MEASURES

Because of the nature of the diseases attacking Bermuda onions in fields planted to small-bulb onions or near plantings of the small-bulb onions, the following measures will be found helpful in controlling such diseases:

1. *Sanitation.*—When infection has just started, the spread should be prevented by pulling the plants and burning them right on the infected spots.

2. *Spraying.*—Bordeaux mixture or dusting with sulphur powder or copper lime dust once a week to obtain effective results may be used.

3. *Soil sterilization and crop rotation.*—Since the fungi causing onion diseases hibernate in the soil, it is advisable to practice long crop rotation in infected fields and soil sterilization by burning dried grasses or trash on the plots before planting. This is specially advisable in seed beds. This treatment should involve plenty of burning and stirring the soil with a rake. The ashes may be raked during the final preparation of the soil.

4. *Time of planting with relation to control of diseases.*—There is observed to be a slight damage to young plants; therefore planting should be timed so that by February the bulbs are already big.

Smut (*Urocystis cepulae*).—Dark pustules appear within the leaves or scales and may split open, exposing black powdery masses, principally on the young seedlings.

Fusarium rot (*Fusarium* spp.).—A rapid dying back from the tips of the leaves, accompanied by a rot starting at the base of the bulbs.

White rot (*Sclerotum cepivorum*).—A condition of the tops quite similar to Fusarium rot but differing in that round dark brown bodies appear in the diseased bulbs.

Pink rot (*Fusarium malli*).—The roots turn pink and die; new roots are attacked as they develop, resulting in a marked stunting of the plant.

Rust (*Puccinia porri or P. asparagi*).—Orange or golden yellow pustules appear on the leaves or seed stems, especially on those of the Egyptian onion.

Dodder (*Cucusta* sp.).—A creeping or twining, leafless plant attacks leaves of onions, often killing the tops in roughly circular areas in the field.

Root-knot (*Heteroders radicicola.*)—The leaves become a sickly green; swellings form on the roots.

Thrips (*Thrips tabaci* Lindeman).—Small white chafed spots appear on the leaves causing them to die prematurely; the minute pale-yellow thrips which cause the injury are commonly present.

Onion maggots often kill seedlings by feeding on the roots.

DISEASES IN STORAGE AND IN TRANSIT

Neck-rot (*Botrytis* sp.).—A rot begins at the neck of the bulb and progresses downward; the tissue shrinks and collapses; a gray to brown moldy growth and hard, black kernels later appear on the surface of the affected scales.

Soft-rot.—A rot that begins at harvest time or later, but differs from neck rot in that it is softer and more watery, usually with a very offensive odor.

Fusarium rot (*same organism as that in the field disease*).—A semi-watery rot advancing from the base of the scale upward.

Black molds (*Aspergillus niger*).—Black, powdery masses form, not in definite pustules within the scales, as in smut, but on the outer surface of the scales or between them.

Smudge (*Collectotrichum circinans*).—Smudgy, superficial black spots made up of fine dots, but with no powdery masses, appear shortly before harvest time on the outer scales; primarily on white varieties.

Mold (*Macrosporium porri*).—A semi-watery decay, at first deep yellow, then wine red and finally black, attacking the neck or wounds in the scales, which dry down in a papery texture.

ECONOMICS OF ONION PRODUCTION

TABLE 2.—*Estimate of cost of production by the field or row-method of culture (not including land tax and interest on investment and depreciation) on one hectare of land.*

Items of operations	One hectare		
	Man days	Animal days	Cost approximately
1. Cost of seeds, 4 kilos			₱48.00
2. Seed bed preparation and sowing	6		6.00
3. Care of nursery (watering, making of shades, disinfection, thinning, etc.)	60		30.00
4. 1st plowing	7	7	10.50
5. Harrowing	2	2	3.00
6. 2nd plowing	5	5	7.50
7. Harrowing	2	2	3.00
8. 3rd plowing	5	5	7.50
9. Harrowing	2	2	3.00
10. Furrowing	1	1	1.50
11. Transplanting	30		10.00
12. Cultivation (5 times)	2	2	15.00
13. Weeding (4 times)	30		48.00
14. Irrigation charges (Government charges)			12.00
15. Furrowing (4 times)	1	1	6.00
16. Harvesting, Stacking and Curing	6		6.00
17. Hauling	3	3	4.50
18. Packing			14.00
19. Crating	8		8.00
Total			243.50

Cost of production per kilo as per above figures:

At 7,000 kilos per hectare	₱0.035
At 8,000 kilos per hectare	0.031
At 13,000 kilos per hectare	0.091
At 14,000 kilos per hectare	0.017

Based on the 1929 importations of onions, the average wholesale price per kilo is approximately ₱0.06. Thus there will still be realized a reasonable net profit from the minimum yield of 7,000 kilos per hectare.

TABLE 3.—*Cost of production by intensive culture (excluding land tax and interest on investment and depreciation) of one hectare of Bermuda onion plantation with irrigation, grown during the 1933–34 planting season.*

Items of operation	Cost
1. Cost of seeds, 2.5 kilos at ₱8 a kilo	₱20.00
2. Preparation of seed beds and sowing, 200 square meters	43.50
3. Care of nursery	7.50
4. 1st plowing	12.00
5. 1st harrowing (including lifting of weeds and throwing them away, etc.)	24.00
6. 2nd plowing	12.00
7. 2nd harrowing	12.00
8. 3rd plowing	12.00
9. 3rd harrowing	12.00
10. Preparation of field for planting (bed system)	37.50
11. Transplanting (including lifting of seedlings, distribution of same, watering, etc.)	90.00
12. Irrigation, 3 times	22.50
13. Weeding and cultivation, 3 times	37.50
14. Harvesting	7.50
15. Hauling, cutting of leaves, drying in sun curing, etc.	82.50
16. Crating, etc.	7.50
Total	440.00

This project was done under the administration of an experienced Bermuda onion planter. The expenses incurred in some of the items are quite high. In the preparation of seed beds a big amount was spent as the land was infested with persistent weeds. The thoroughness of the preparation of the seed beds was manifested by the very low amount spent in their care. The first harrowing was also expensive as the roots of weeds had to be gathered thoroughly. Transplanting, including pulling of seedlings and distributing them in the field and watering the newly transplanted plants by the bucket system, was laborious and hence quite expensive. A big amount was likewise spent in item No. 15 because the process of drying the onions in the sun repeatedly and curing them without the use of curing sheds and separating rotten from good onions, necessitated plenty of labor. This was done to insure good keeping quality. Laborers were hired at ₱0.50 per day and plowmen at ₱0.80.

A crop of 18,900 kilos was obtained from this farm. The wholesale price at the farm was ₱0.06 per kilo, while prices in Manila ranged from ₱3.20 to ₱3.70 per sack of 40 or 45 kilos.

By the tenant system of raising onions, even if prices are much lower than herein given, under favorable conditions both the land owner and the tenant will have a good margin of profit. The flooding of the markets occasioned by the importation of cheap onions from Japan may prove disastrous to onion planters in the Philippines, but due to high yields grown under favorable conditions, it may be safely concluded that onion growing should bring a reasonable margin of profit. The fact is herein emphasized that the Bermuda onion has a better eating quality (although quite inferior in keeping quality) than the common "strong" onions ("sibuyas Bombay") imported into the Philippines.

REFERENCES

ANONYMOUS, Onion Diseases and Their Control. U. S. Department of Agriculture. Farmers' Bull. No. 1060.

ANONYMOUS, Onion Culture, U. S. Department of Agriculture. Farmers' Bull. No. 354.

ILLUSTRATIONS

PLATE 1

FIGURE 1. A Yellow Bermuda onion field showing the system of single row planting and cultivating by animal drawn cultivator.

2. The same field in Figure 1 showing the close-up view of double row planting. Note the furrows between the double rows which served as irrigation canals.

PLATE 2

FIGURE 1. A group of Yellow Bermuda onion plots planted directly by seeds.

2. A Yellow Bermuda onion plantation planted by seedlings in plots. Weeding and cultivating were exclusively done by hand labor and the paths between the plots served as irrigation canals.

PLATE 3

FIGURE 1. A Yellow Bermuda onion filed showing the growth and development of bulbs on sandy loam soil along the seashore.

2. Bulbs of Yellow Bermuda onion showing the formation of the proper size of neckstems—a characteristic of good curing.

PLATE 4

FIGURE 1. Bulbs of Red Bermuda onion showing the formation of thick neckstems—very objectionable for proper curing.

2. Abnormal development of Yellow Bermuda onions caused by a malady locally known as "Pasik." The primary attack is caused by Thrips (*Thrips tabaci*) and the secondary attack is caused by several fungi.

PLATE 5

FIGURE 1. A view of freshly harvested onions spread thinly on the ground for sun curing.

2. A view of sun cured onions preparatory to sacking.

TEXT FIGURE

FIGURE 1. Curing shed calculated to have a space of 864 square meters for drying. It will hold from 15,000 to 20,000 kilos of onion bulbs. Batteries A, B, and C, are shelves 120 cm. wide running longitudinally along the shed with 50 cm. each way down and above the others.

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2

PLATE 1.

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PLATE 2.

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PLATE 3.

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PLATE 4.

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PLATE 5.

EFFICIENCY OF CITRUS ORCHARDS IN TANAUAN CITRUS STATION

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The Batangas mandarin, *Citrus nobilis* Lour., which is commonly known as *Sintones* or *Dalanjita* in Tagalog, *Lulukisen* in Ilocano, is the most important citrus species in cultivation in the Philippines. It has been and is extensively grown in the Province of Batangas. To give credit to the province which gives this mandarin commercial importance, it is but fitting to name the variety "Batangas mandarin." In some recent literature on *Citrus* in the Islands pertaining to mandarin, this name has been used to designate this particular variety. Batangas mandarin was introduced into the Islands very long ago. There is great similarity between Batangas mandarin and Suntara (*P. I. No. 1262*) which was introduced in 1912 from Saharanpur, India. In 1912, Tanaka(6) identified Ponkan, *Citrus poonensis* Hort. ex Tanaka, with Suntara, an orange of Poona. Our Ponkan, *P. I. No. 9897*, introduced from Tiapeh, Formosa, Japan, in 1927, has not yet fruited, but in stem and leaf characteristics it is more or less similar to the Batangas mandarin. It may be possible therefore to identify the Batangas mandarin with Ponkan and Suntara. The traders in early days may have brought this variety into the Islands directly from India, although many investigators believe that it is indigenous to Cochin-China.

The Batangas mandarin may be considered superior in eating quality to most other mandarins recently introduced and grown in the Philippines(8); the late Horticulturist P. J. Wester so regarded it(1).

The most common method of propagating *Citrus* in the Philippines is from seeds. Being a genus with species and varieties that are so generally heterozygous(2, 3) and propagated from seeds, it is to be expected that variation in yields, types and qualities of fruits, types of trees and fruiting habit, should be common. This being so, old orchards in the Philippines should offer excellent material for the selection of superior trees.

Prior to this report there has been no selection of productive Batangas mandarin trees based on individual performance, as there were yet no data. The Government had to content itself either with owners' statements about their trees, or with one or two years' casual observation of bearing trees, budsticks from trees believed to be superior being then collected for propagation in the Government stations. In this way some twenty-three strains have been isolated at the Tanauan Citrus Station. Of this number, two seemingly superior or rather promising types, *P. I. No. 8865* and *P. I. No. 8868*, have been extensively propagated and were recommended for commercial planting(4) until some more productive trees can be found by judicious selection.

Important bud- or branch-mutants are very seldom found in the Batangas mandarin. From several thousand trees in the station and vicinity, observed during the last fifteen years, only one branch-mutant, from tree *B298*, has been isolated. It produces fruits of excellent quality, is early bearing, and its branching is very much improved as compared with the common type. This particular mutant, judged by the mother tree, as well as by its buds topworked on other old trees, has proved to be a regular bearer.

OBJECT OF THE PRESENT STUDY

This study was undertaken for two purposes; first, to determine the efficiency of the different orchards of the station, consisting of trees grown from seedlings, and second, to select on the basis of ten-year production, (1924–1933, inclusive), a number of high-yielding trees from which to get budsticks for commercial propagation. High productivity is here considered of paramount importance, although other important characteristics, such as size, uniformity, and quality of the fruits, are not to be overlooked in the process of selection.

MATERIALS AND METHODS

The trees in the orchards under consideration were about eighteen to twenty-three years old when they were acquired by the Government in July, 1919. These trees, according to information, were fruitful prior to the eruption of Taal Volcano on January 29, 1911. After that incident, the combined effects of a long dry season in 1911 and the prevalence of bark-rot disease, together with poor orchard management, reduced the production of fruit to nil. Most of the trees within and near

the station suffered very severely and many of them died. Many citrus groves were wiped out entirely.

When the Government acquired these orchards, they were wholly neglected; weeds, shrubs, and wild trees were abundant. The surviving citrus trees were sickly and covered with *Loranthus*, a plant parasite.

The identity of each tree was first established. Three orchards were designated A, B, and K, and the trees in each were numbered, as A–1, B–1, K–1, and scattered trees were given the initial letter S. Numbers were painted on the trunks with lead paint facing in one direction, about 1.5 meters above the ground.

General clearing was done as fast as possible, and clean cultivation was then maintained. Catch crops of rice and corn were grown in rotation with some leguminous crops. Close observation of the health of the trees for about three successive years showed that clean cultivation and cropping did not improve their condition; much to our surprise, many trees continued to die, in spite of good care and practical control of diseases.

Common local experience with the Batangas mandarin was that these trees were quite indifferent to constant cultivation, therefore it was the local practice to allow the citrus orchards to run to grass and weeds of all sorts. Madre cacao, *Gliricidia maculata*, was sometimes used as shade for citrus; and was allowed to grow too high, thus impairing the health of the citrus trees.

The station, therefore, turned its attention to the use of permanent cover crops, only modifying the old practice. Legumes were used as cover and green manure crops. Cover crops were not allowed to grow too tall, but were cut at frequent intervals so as not to shade the citrus trees but to furnish abundant green manure. Early in 1923 Orchard A was planted partly with *Tephrosia candida* and madre cacao, Orchard B with madre cacao alone and Orchard K with ipil-ipil, *Leucaena glauca*. After a little over a year of this treatment the trees were recovering rapidly, and several trees started to produce good crops in 1924.

Trees in the orchards were planted in regular rows, about seven meters apart. The scattered trees, however, are mostly along the road and in off-places in the newly established orchards. Orchards A and B are more or less rolling and easily drained, and the soil is of medium sandy loam and rich loam soil enriched annually by soil debris from neighboring higher lots. At the beginning of the experiment in 1924, Orchard A contained

114 trees, Orchard B, 328 trees; Orchard K, 57 trees; and there were 123 scattered trees.

Beginning November and December, 1929 a complete fertilizer was applied regularly to all orchards, including scattered trees, at the rate of two kilograms per tree per year. Three years after, instead of a single dose, two applications of one kilogram fertilizer to each tree were made, beginning at the close of the rainy season, October and November, 1932, while the trees were in fruit; and the second half-dose was applied in the early part of the rainy season, April and May, 1933.

Collection of yield.—The yields of individual trees were gathered in two counts. At first the estimate was made three to four weeks before maturity, and in the second, the actual number of fruits was taken at harvest. In estimating the yield of a tree the procedure depends upon the size of the crop. The fruits are actually counted when the tree bears about five hundred fruits or less. A heavier crop is determined by first quartering the tree and then counting the number of fruits in one quadrant only, if the branches are more or less uniformly loaded. The number of fruits thus obtained is multiplied by four. In case the fruits are unevenly distributed in the tree the fruits in two quadrants representing half of the whole crops are counted, and the count obtained is multiplied by two. Two estimates are taken on the same day and the average of the two determinations is considered the estimated yield of the tree for that year.

The actual count of fruits at harvest is corrected whenever necessary and is considered the yield of the tree for the year. In case for some reason or other the number of fruits at harvest cannot be obtained, as in 1931, the estimated yields are used as final.

In spite of the fact that there were trees which in some years have produced very heavy crops, no thinning was practised during the last ten-year trial. Generally during and after high winds more damage is done with a lighter than with a heavier crop. As the trees grown from seedlings were not trained or pruned low, they generally grow very tall, and as the fruits are easily detachable from the stem—a poor characteristic of the variety(8)—they are indeed very susceptible to windfall. Unless the orchards are adequately protected from high winds by means of windbreaks, thinning of young fruits from heavily loaded trees would seem not very advisable.

The number and percentages of bearing and nonbearing trees every year, and the average yearly production, are presented in Table 1. Table 2 gives the number of trees that have survived the test and their distribution according to their yielding capacity, based on total fruit production for ten years.

Table 3 shows the production of the 32 highest-yielding trees from the different orchards; 10 trees of Orchard A, 9 trees of Orchard B, 11 trees of Orchard K, and 2 of the scattered trees.

A method of comparison based on the ratio of individual yields to the average yearly production of bearing trees in their respective orchards is also presented. The relative yield ratios, and their averages, are shown in Table 4.

GENERAL REMARKS

Before discussing the results it is of interest to consider the relation of climate to citrus production. Climate plays an important rôle in the production of Batangas mandarin, as experience has shown that, although it requires a certain amount of precipitation for the normal vegetative development and fruiting of citrus in non-irrigated areas and far from the lake shores, there is a climatic deviation that is considered favorable for the production of a normal crop. This plant needs, after the rainy season, a period of warm days with a short dry spell in order to insure a heavy blooming. Thus, when warm days start early in January extending through February and then a heavy rain falls in March, the fruiting season for the year will be quite early. On the other hand, if cool days continue well into February followed by warm days in March and April and then with a heavy rain late in May or June the resulting crop will be a late one. Heavy rainfall in April after a period of warm days is conducive to heavy blooming with a resultant good crop.

Constant showers and cool days throughout the winter and spring months are unfavorable to flower production. Instead, most of the trees undergo vegetative development, with the result that the crop becomes very light or practically nil. Such weather occurred in 1928 and was followed by an abnormally small crop. Likewise, in 1932 and 1933 the weather was not very favorable to citrus production, for the cool days lasted well into the spring months; nevertheless the crops in those years were larger than that of 1928.

Another point of interest to be considered in this connection is the fact that the crops during the first five-year period were smaller than during the second or last five years. Several possibly responsible factors may be mentioned, but it is not possible to show the degree of influence exerted by each of them separately.

During the first period, the trees were in the process of vegetative recovery from the effect of heavy root pruning caused by previous clean cultivation or plowing, which was observed to be quite detrimental to the health and life of the trees. The general attack by bark-rot and pink diseases, pests, and plant parasites, had rendered the trees less productive. Any advantages that might have been derived from permanent cover cropping are more manifest during the second period than during the first. The advantages of cover-cropping that might be mentioned are: (*a*) increase of organic matter or humus in the soil; (*b*) prevention of erosion; (*c*) probably an increase in the nitrogen content of the soil; (*d*) perhaps a favorable condition for biological growth in the soil, due to shading and the presence of humus; and (*e*) the increase of soil moisture, preventing nefarious wilting of trees during warm days and drought. Be sides, the application of fertilizer, which was started in 1929 helped to increase the average production in later years. Although all these factors may have contributed to an increase in the average production, it is believed that the extent of their effect, though not measured, would not invalidate the value of the results obtained.

The last, but not the least, points of importance to be considered in studying the relative efficiency of the orchards are the different groups of factors which determine the productivity of a tree. At least three groups of factors should be recognized, namely: (*a*) The cultural practices which are under the control of the grower; (*b*) the orchard environment and its relation to cultural practices; and (*c*) those which have to do with the inherent character of the trees themselves. Thus, according to Hodgson(7), the best results are obtained when an optimum combination of these groups is maintained. He also believes that environmental conditions as related to cultural practices, which cause most of the wide variation in yields, can be controlled at least partially, and he, therefore, suggests that these factors should be given due attention so as to improve the productivity of the orchards.

DISCUSSION OF RESULTS

Examination of data presented in the tables will show that the yields of individual trees vary from year to year; and so then does the total and average production of bearing trees in different orchards (Table 5). That a large number of trees are more or less consistently low producers, is very evident in Orchards A and B and in scattered trees. It appears that low-producing trees are generally in groups or zones in the orchards instead of being uniformly scattered over the whole orchards, a fact which indicates that orchard environment, rather than inherent quality, is in a large measure responsible for the low productivity of most trees. Unless the effects of these unfavorable environmental factors are corrected by proper orchard practices, many of the inherently productive trees, which because of adverse conditions have poor performance records, must remain poor yielders.

There is a general belief among citrus fruit growers that the death of a tree is preceded by a very heavy crop. Whenever a tree is heavily loaded with fruits the usual prediction is that its death will ensue in the following dry season. Station records of the death of 104 trees from 1924 to 1933, inclusive, show that only 11 trees produced a more or less heavy crop in the year preceding their death, indicating that only slightly more than once in ten cases is the above presumption borne out.

Table 1 shows that in 1929 a bumper crop was produced. With a favorable climate for citrus fruit production in that year, and an abnormally small crop in 1929, such a large crop as that in 1929 may be expected. The second best crop was produced in 1931 after a rather lean crop in 1930. Table 5 shows that in general alternate year production is usual with the Batangas mandarin unless unfavorable weather interferes with the crops in successive years, as in 1932 and 1933.

RELATIVE EFFICIENCY OF DIFFERENT ORCHARDS

In connection with the relative efficiency of orchards the following important points are to be considered: (*a*) percentages of bearing and nonbearing trees; (*b*) average production of bearing trees and of all trees; and (*c*) percentages of unprofitable, self-supporting, and profitable trees.

(*a*) *Percentages of bearing and nonbearing trees.*—A mandarin orchard with trees grown from seedlings, not budded,

which shows at least 80 per cent bearing trees, may be considered normal with respect to this character. For budded trees of bearing age a standard 15 per cent higher than for seedling trees may be required. Table 5 shows that the percentages of bearing trees in different orchards vary from year to year; and as the percentage of bearing trees increases there is also an increase in the average production, which shows that up to a certain limit there is a close relationship between these two characters. It is also evident that during the first five years less trees were fruiting in proportion to the total number than during the second period of five years. In this connection the first five years may be designated as an abnormal period and the second five years as a normal period.

During the first five years, or abnormal period, the average percentage of trees that fruited was 48.08 per cent in Orchard A, 47.5 per cent in Orchard B, 45.96 per cent in Orchard K, and 29.38 per cent of the scattered trees. During the normal period, Orchard A showed 89.6 per cent, B gave 82.34 per cent, K showed 91.84 per cent, whereas the scattered trees gave only 79.89 per cent. Taking all orchards and scattered trees together the bearing trees composed 43.69 per cent during the first period as compared with 84.12 per cent during the normal period. For ten years the average percentage of bearing trees was 68.84 in Orchard A, 65.12 per cent in Orchard B, 68.9 per cent in Orchard K, and 54.64 per cent in scattered trees, a general average of 63.91 per cent. During the abnormal period only Orchard A gave 82.80 per cent, in 1927, which is above the normal mark of 80 per cent. Orchard K showed the highest, and the scattered trees the lowest, percentage of bearing trees during the normal period; but none of the orchards showed a normal average percentage of bearing trees for the whole 10 years.

(*b*) *Average production of bearing trees and of all trees*—With the Batangas mandarin at bearing age an average yield of 100 fruits or less per tree is indeed a poor crop, as the income that may be derived from it is not sufficient to cover the production costs. Yields ranging from 101 to 250 may be considered hardly fair crops, inasmuch as the value of the produce will barely cover the cost of production. Any yields larger than 250 fruits per tree, considering the current price of mandarin fruits, would give a margin of profit to the grower, hence such yields may be considered good crops.

In the arbitrary classification of crops it will be noted that Orchard A produced good crops in 1929 and 1931, fair crops in 1927, 1930, and 1932, and poor crops in the other five years. The average production for the first period was very poor—only 48.88 fruits for bearing trees and 30.78 fruits for all trees. The average yield for the second period was 221.83 fruits for bearing trees and 202.60 fruits for all trees; both averages are fair or almost good.

Orchard B gave good crops in 1929 and 1931, fair crops in 1926, 1930, and 1932, and poor crops in the other five years. The average yields during the abnormal period were 63.37 fruits for bearing trees and 36.68 fruits for all trees; whereas in the normal period the averages were 193.49 fruits for bearing trees and 168.43 fruits for all trees. For ten years the average production was 128.43 fruits for bearing trees and 102.56 fruits for all trees. Orchard B gave a higher average production in the first period, but a lower one than Orchard A in the second period.

Orchard K gave good crops in 1927, and 1931, fair crops in 1924 and 1930, an almost fair crop in 1924 and poor crops in the other four years. In the first period the average production was 157.1 fruits for bearing trees, and 99.75 fruits for all trees; in the second or normal period the averages were 549.56 fruits for bearing trees and 533.13 fruits for all trees. The average production for ten years was 353.33 fruits for bearing trees and 316.44 fruits for all trees. These data show that Orchard K was almost self-supporting during the abnormal period and indeed was profitable during the normal period. Even considering the produce for the whole ten years that orchard has given a good crop on the average.

The scattered trees gave only fair crops in 1929 and 1930, an almost fair crop in 1931, and poor crops in the other seven years. The average production was 39.77 fruits for bearing trees and 11.82 fruits for all trees during the first period. In the second period, however, the averages were 134.21 fruits for bearing trees and 105.45 fruits for all trees. The averages for ten years were poor, being 86.99 for bearing trees and 58.63 fruits for all trees.

Taking together all trees in different orchards the averages during the first period were 71.19 fruits for bearing trees and 37.34 fruits for all trees, and during the second period the averages were 228.10 fruits for bearing trees and 198.54 fruits for all trees, while the averages for ten years were 179.65 fruits

for bearing trees and 117.94 fruits for all trees. The above data indicate that Orchards A and B and the scattered trees produced poor average yields, but Orchard K gave a fair or an almost fair average crop during the first five years. In the second period, however, orchard K showed good average yields, and Orchard A almost good, and the others only fair average yields. The average production for ten years was only fair for Orchard A and B, good for Orchard K, and poor for scattered trees. All trees, in the orchards and scattered trees taken together, gave a poor average production during the abnormal period and a fair or an almost good average yield during the normal or second period, but the ten-year averages were hardly fair, even counting the bearing trees only.

(*c*) *Percentages of unprofitable, self-supporting, and profitable trees.*—In accord with the preceding classification of yields it may be stated that the trees producing poor average yields may be classified as unprofitable trees or "boarders," those producing fair crops may be classified as "self-supporting" trees; and the ones giving good crops may be classified as "profitable" trees. It is evident that the value of any orchard depends upon the relative proportion of these three classes of trees. Hence, the trees were grouped into different classes according to their individual production. Only those trees which survived the test were included in this classification, however.

Table 2 shows that the highest total individual tree production, about 6,500 fruits, was obtained in Orchard K; the highest in orchard B was about 5,000 fruits; in Orchard A the highest was about 4,500 fruits; and the highest of the scattered trees was about 3,000 fruits.

The 81 living trees in Orchard A are divided into three classes: 55.56 per cent unprofitable trees or "boarders;" 32.1 per cent self-supporting trees; and only 12.34 per cent profitable trees. In Orchard B, 220 trees are classified as 65.46 boarders, 28.63 per cent self-supporters, and 5.91 per cent profit-returners. The 39 trees in Orchard K are classified as 15.39 per cent boarders, 33.33 per cent self-supporting and 51.28 per cent profitable trees; and out of 98 scattered trees 80.61 per cent are boarders, 17.35 per cent self-supporters, and only 2.04 per cent profitable. Taking all living trees into consideration, there are 438 trees, grouped as: boarders, 62.56 per cent; self-supporters, 27.17 per cent; and 10.27 per cent profitable trees.

The above data show that Orchard K, with 39 living trees, has the highest percentage of profitable trees. Because of the small number of trees in this orchard compared with other groups, its percentages cannot be given too much weight in comparison. Except for Orchard K, it may be stated that none of the groups showed higher than 13 per cent profitable trees. In fact with all trees taken together there are out of 438 trees only 45, or 10.27 per cent, that may be classified as profitable.

SELECTION OF HIGH-YIELDING TREES

In the preceding discussion the trees have been classified as unprofitable and profitable. It is very well understood that some trees that are classified as unprofitable may be inherently high yielders, unproductive because of some unrecognized unfavorable peculiarity of the individual environment. At present there is no practical way by which they can be singled out from the inherently low-yielding trees. On the other hand, not all trees having high total yields are inherently productive; they produce good crops, and are grouped with the profitable trees, because of favorable factors other than genetic. The best and surest method of selecting productive trees of highest order, in the genetic sense, is of course, by testing their clonal lines under more or less uniform field or orchard conditions. The orchards under study are indeed far from being uniform, as their description has shown.

For the present, in order to select even approximately the best of these high-yielding trees, one should determine those trees that are consistently high yielders, i. e., those tending to produce good crops from year to year. In this connection the method of approach suggested is a comparison based on the ratio between individual yields and the average yearly production of bearing trees in their respective orchards or groups.

The relative yield ratio and the average yield ratio of individual trees selected from the different groups as shown with their individual production in Table 3, are presented in Table 4. To narrow the field, only 31 of the 45 profitable trees have been included in this comparative study; and tree No. A99, which died in 1931, is added. This particular tree is survived by some of its clonal progeny which were propagated prior to its death. The average yield ratios in table 4 are also shown in Table 5, which also presents the average production of individual trees systematically arranged from the lowest to highest. The fourth

column of Table 5 shows the number of years in which the individual yields exceeded the average production of bearing trees.

The ten-year average production of the highest yielding trees, selected for comparative study, ranges from 258.2 fruits to 625.5 fruits, whereas the average yield ratio varies from 0.93 to 4.59. From these two series of data it can be realized that the average yield ratio runs more or less independently of the average production. In other words, trees having high average yields are not necessarily high in their average yield ratio.

The number of years of above-average yield, column 4, Table 5, varies from three to eight. It appears from the data presented that out of the 32 trees under study, 12 trees yielded in excess of the average production of bearing trees in their respective group in five of the ten years; 10 trees in less than five years; and the other 10 trees in more than 5 years.

SELECTED BATANGAS MANDARIN TREES

On the basis of the data presented in Table 9, it may be stated that the trees that are consistently high producers should not only show a high average yield and a relatively high average yield ratio, but also that the annual yield should be higher than the yearly average production of bearing trees in their respective orchard for more than five in ten years.

Selection 1.—Tree No. B132 is easily the best and the most consistent high yielder. It has an average production for ten years of 426.2 fruits and an average yield ratio of 4.59, and for eight of the ten years its individual yields are higher than the yearly average production of bearing trees in Orchard B.

Selection 2.—The next best tree is K23 which gave an average yield of 625.5 fruits for ten years, an average yield ratio of 2.54, and its yearly yields for seven of the ten years are higher than the corresponding yearly average production.

Selection 3.—Tree K34 is the third best tree with an average production of 469.6 fruits for ten years and an average yield ratio of 2.44. Its yields are in excess of the average yearly production for seven of the ten years.

Selection 4 to 12, inclusive.—Other good trees that are more or less consistent yielders are K4, K31, B135, B158, A13, B152, A15, A11, and S24. With more rigid selection, using 300 fruits as the minimum tolerable average production, only eight trees would be selected, eliminating the last four of those enumerated

above. It must be noted, however, that, with the exception of A13 and B135, all the selected trees have their annual yields exceeding the yearly average production in more than five years. The reason for including these two trees is that Tree A13 is the highest both in average production and in average yield ratio in Orchard A; and Tree B135 outyielded Tree B132, Selection No. 1, and is second to it in average yield ratio.

SUMMARY AND CONCLUSION

The first five-year period was characterized by low average percentage of bearing trees and low average production, as compared with the second five-year period. During the first period Orchard A showed an average of 48.08 per cent bearing trees; Orchard B, 47.5 per cent; Orchard K, 45.96 per cent; and the scattered trees, 29.38 per cent. In the seccond five-year period, Orchard A had 89.6 per cent bearing trees; Orchard B, 82.34 per cent; Orchard K, 91.84 per cent; and scattered trees 79.89 per cent. All trees taken together showed an average of 43.69 per cent bearing trees in the first period and 84.12 per cent in the second period.

The average production of bearing trees in the first period was 48.88 fruits in Orchard A; 63.37 fruits in Orchard B; 157.10 fruits in Orchard K; and 39.77 fruits for scattered trees; as compared with averages in the second period, of 221.83 fruits in A; 193.49 fruits in B; 549.56 fruits in K; and 134.21 fruits for scattered trees. All bearing trees taken together, the average production was 71.19 fruits in the first period and 228.10 fruits in the second period. These data, notwithstanding the possible effect of climatic variations, seem to indicate that the use of fertilizers, in combination with cover cropping, has increased the production of Batangas mandarins very materially. However, it is not yet well proven that their use in these orchards has been profitable.

The profitable trees constitute 12.34 per cent in A; 5.91 per cent in B; 51.28 per cent in K; and 2.04 per cent of scattered trees. Out of the total of 438 living trees, only 45 trees, or 10.27 per cent, were profitable. Orcahrd K is the most productive orchard, and Orchard A is a poor second in productivity.

The fact, that a large majority of the trees are operated at a loss, has been emphasized. Orchard environment, rather than genetic factors, are in most cases responsible for the low productivity, and it is suggested that special attention be given the

poor yielding trees, the productivity of these orchards as a whole is to be improved.

A method of comparison based on the average yield ratio is also suggested. Based on this method it is indicated that a superior tree is characterized not only by high average yield and high average yield ratio, but also by annual yields consistently exceeding the average production of bearing trees in the same orchards.

Out of 45 profitable trees there have been selected twelve that are considered consistent yielders; B132, K23, and K34 are the three best trees.

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TABLE 1.—*Number and percentages of bearing and non-bearing trees and average productions of orchards, A, B, and K and scattered trees, from 1924 to 1933 inclusive*

ORCHARD A

Year	Total	Number of trees		Percentage		Total production	Average production of bearing trees	Average production of all trees
		Bearing	Non-bearing	Bearing	Non-bearing			
				Per cent	*Per cent*			
1924	95	27	68	28.42	71.58	734	27.18	7.72
1925	94	23	71	24.47	75.53	544	23.65	5.78
1926	94	57	37	60.64	39.36	3,109	54.54	33.07
1927	93	77	16	82.80	17.20	9,158	118.93	98.47
1928	93	41	52	44.09	55.91	825	20.12	8.87
1929	92	86	6	93.48	6.52	33,805	393.08	367.44
1930	91	82	9	90.11	9.89	9,397	114.09	103.26
1931	90	87	3	96.67	3.33	29,536	339.49	328.17
1932	88	77	11	87.50	12.50	7,143	96.27	81.17
1933	81	65	16	80.20	19.75	10,771	165.71	132.98
1924–28 average	93.8	45.0	48.8	48.08	51.92	2,874	48.88	30.78
1929–33 average	88.4	79.4	9.0	89.60	10.40	18,130.4	221.83	202.60
Average for 10 years	91.1	62.2	28.9	68.84	31.16	10,502.2	135.36	116.69
ORCHARD B								
1924	279	128	151	46.07	53.93	7,285	56.91	26.10
1925	278	97	180	34.89	65.11	1,723	17.76	6.19
1926	278	186	92	66.81	33.09	31,683	170.33	113.96
1927	278	149	129	53.60	46.40	9,405	63.12	33.83
1928	278	106	17	38.13	61.87	924	8.71	3.32
1929	275	256	19	93.09	6.91	100,294	391.77	364.70

TABLE 1.—*Number and percentages of bearing and non-bearing trees and average productions of orchards, A, B, and K and scattered trees, from 1924 to 1933 inclusive*—Continued

Year	Total	Number of trees		Percentage		Total production	Average production of bearing trees	Average production of all trees
		Bearing	Non-bearing	Bearing	Non-bearing			
				Per cent	*Per cent*			
1930	266	236	30	88.76	11.24	28,420	120.42	106.84
1931	245	207	38	84.49	15.51	55,665	268.91	227.20
1932	229	183	46	79.92	20.08	27,155	148.38	118.58
1933	220	144	76	65.46	34.54	5,465	37.95	24.84
1924–28 average	278.2	133.2		47.50	52.08	10,204.0	63.37	36.68
1929–33 average	247.0	205.2	145.0	82.34	17.65	43,399.8	193.49	168.43
Average for 10 years	262.6	169.2	93.4	65.12	34.87	26,801.9	128.43	102.56
ORCHARD K								
1924	57	32	25	56.14	43.86	5,267	164.59	92.40
1925	57	17	40	29.82	70.18	296	17.41	5.19
1926	57	28	29	49.12	50.88	2,709	96.75	47.52
1927	57	40	17	70.18	29.82	20,104	502.60	352.63
1928	57	14	43	24.56	75.44	58	4.14	1.01
1929	57	56	1	98.25	1.75	58,756	1,049.21	1,030.80
1930	53	51	2	96.23	3.77	12,566	245.61	236.34
1931	45	44	1	97.78	2.22	57,461	1,305.90	1,276.88
1932	41	35	6	85.37	14.63	2,835	81.00	69.14
1933	39	31	8	81.58	18.42	2,047	66.03	52.48
1924–28 average	57.0	26.2	30.8	45.96	54.04	5,686.8	157.10	99.75
1929–33 average	47.0	43.4	3.8	91.84	8.16	26,725.0	549.56	533.13
Average for 10 years	52.0	34.8	17.2	68.90	31.10	16,205.9	353.33	316.44

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SCATTERED TREES

1924	109	20	89	18.34	81.66	1,490	74.50	13.67
1925	108	18	90	16.67	83.33	160	8.88	1.48
1926	108	39	69	35.78	64.22	1,669	42.79	15.45
1927	107	57	50	53.27	46.73	2,229	39.10	20.33
1928	105	24	81	22.86	77.14	806	33.58	7.67
1929	104	96	8	92.31	7.39	20,236	210.79	194.57
1930	102	86	16	84.31	15.69	6,271	72.92	61.48
1931	99	62	37	62.63	37.37	13,739	221.59	138.77
1932	98	79	19	80.61	19.39	8,533	108.01	87.07
1933	98	77	20	79.59	20.41	4,445	57.72	45.35
1924–28 average	105.4	31.6	75.8	29.38	70.61	1,270.8	39.77	11.82
1929–30 average	100.2	80.0	20.0	79.89	20.11	10,644.8	134.21	105.45
Average for 10 years	103.8	55.8	47.9	54.64	45.36	5,957.8	86.99	58.63

ORCHARDS A, B, K, AND SCATTERED TREES

1924	540	207	333	38.45	61.55	14,776	71.38	27.36
1925	537	155	382	27.01	74.99	2,723	17.56	5.07
1926	537	310	227	57.73	42.27	39,170	126.35	72.94
1927	535	323	212	60.56	39.44	40,896	126.61	76.44
1928	533	185	348	34.71	65.29	2,613	14.07	4.90
1929	528	494	34	93.57	6.43	213,091	431.27	403.58
1930	512	455	57	88.89	11.11	56,614	178.07	110.57
1931	479	400	79	83.51	16.49	156,401	391.00	326.51
1932	456	374	82	82.02	17.98	45,666	122.10	100.14
1933	437	317	120	72.61	27.39	22,728	71.69	52.01
1924–28 average	536.4	236.0	300.4	43.69	56.31	20,035.6	71.19	37.34
1929–33 average	482.4	408.0	74.4	84.12	15.88	98,900.0	228.10	198.54
Average for 10 years	509.4	322.0	187.4	63.91	36.09	59,467.8	179.65	117.94

TABLE 2.—*Distribution of old living Batangas mandarin trees in different orchards as to yields and percentages of unprofitable, self-supporting, and profitable trees.*

Classification	Orchard A		Orchard B		Orchard K		Scattered trees		Total	
(Total 10-year production)	*Trees*	*Per cent*	*Trees*	*Per cent*	*Trees*	*Per cent*	*Trees*	*Per cent*	*Trees*	*Per cent*
Trees producing zero to 500	19	23.46	87	39.55	2	5.13	56	57.14	164	37.44
Trees producing 501 to 1,000	26	32.10	57	25.87	4	10.26	23	23.47	110	25.11
Trees producing 1,001 to 1,500	14	17.28	39	17.73	4	10.26	16	16.33	73	16.67
Trees producing 1,501 to 2,000	9	11.11	19	8.63	4	10.26	1	1.02	33	7.53
Trees producing 2,001 to 2,500	3	3.71	5	2.27	5	12.82	0	----------	13	2.97
Trees producing 2,501 to 3,000	9	11.11	7	3.18	5	12.82	2	2.04	23	5.25
Trees producing 3,001 to 3,500	0	0	3	1.36	2	5.13	----------	----------	5	1.14
Trees producing 3,501 to 4,000	0	0	1	.45	4	10.26	----------	----------	5	1.14
Trees producing 4,001 to 4,500	1	1.23	1	.45	5	12.82	----------	----------	7	1.60
Trees producing 4,501 to 5,000	----------	----------	1	.45	1	2.56	----------	----------	2	.46
Trees producing 5,001 to 5,500	----------	----------	----------	----------	1	2.56	----------	----------	1	.23
Trees producing 5,501 to 6,000	----------	----------	----------	----------	0	----------	----------	----------	0	----------
Trees producing 6,001 to 6,500	----------	----------	----------	----------	2	5.13	----------	----------	2	.46
Number and percentages of unprofitable trees	45	55.56	144	65.46	6	15.39	79	80.61	274	62.56
Number and percentages of self-supporting trees	26	32.10	63	28.63	13	33.33	17	17.35	119	27.17
Number and percentages of profitable trees	10	12.34	13	5.91	20	51.28	2	2.04	45	10.27
Totals	81	100.00	220	100.00	39	100.00	98	100.00	438	100.00

TABLE 3.—*Production of productive old Batangas mandarin trees in orchards A, B, K, and scattered trees.*

Tree No.	Yearly production in number of fruits										Total
	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	
A 7	3	8	50	66	5	1,156	205	325	185	910	2,913
A 8		1	7	87	9	1,214	290	85	80	1,128	2,901
A 11	38	2	200	39	17	1,060	192	800	76	230	2,654
A 12	1	11	150	104		1,011	30	1,100		250	2,657
A 13	10	4	250	238	2	1,081	10	1,200	4	1,250	4,049
A 14			15	12	2	1,005	50	800	17	920	2,821
A 15	56	4	150	575	4	688	40	850	15	415	2,797
A 23		13	120	318	1	1,080	5	620	19	450	2,626
A 24			100	557		932	25	870	60	65	2,609
A 99	39	5	10	407	1	1,100	43	2,350	dead		4,055
B 114	17	94	71	439	2	358	675	750	110	66	2,582
B 132	338	78	36	1,255		922	557	590	330	156	4,262
B 135	9	217	1,834	15	7	922	1,076	200	537	19	4,836
B 152	310		40	249	9	841	278	570	64	325	2,686
B 157		21	675	402		1,100	60	120	663		3,041
B 158		12	1,026	554	2	855	210	850	301	21	3,824
B 213	22	1	1,614		4	1,250	180	300	30	6	3,407
B 283	5	2	491	45	25	389	975	70	800		2,802
B 304	45	8	250	60	43	1,488	347	950	81	26	3,298
K 2		3	451	408		1,930	497	850	195		4,334
K 3	13		5	676		1,314	275	1,150	21	15	3,469
K 4	127	5	1	624	2	2,258	55	2,615	150	241	6,078
K 5	288		1	725		1,977	125	1,200	85	55	4,376
K 22	79	1	14	916	5	1,678	139	1,250	25		4,107
K 23	265		550	864		1,793	286	2,300	54	143	6,255
K 31	104	3	20	1,357	6	1,667	297	1,515	23	68	5,060
K 34	25	42	250	985		1,354	413	1,450	165	12	4,696

TABLE 3.—*Production of productive old Batangas mandarin trees in orchards A, B, K, and scattered trees*—Continued.

Tree No.	Yearly production in number of fruits										Total
	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	
K 35	6	25	34	1,035	-------	1,468	142	1,750	4	8	4,472
K 36	-------	-------	-------	129	-------	1,528	446	1,475	19	91	3,688
K 37	-------	-------	-------	17	-------	1,592	408	1,500	46	31	3,594
S 24	2	29	1	30	233	1,150	114	950	42	335	2,886
S 31	33	2	48	11	13	1,273	246	825	-------	210	2,661

TABLE 4.—*Ratio between individual yields and the average yields of bearing trees in their respective orchards.*

Tree No.	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	Average
A 7	0.11	0.34	0.92	0.55	0.25	2.94	1.79	0.96	1.92	5.49	1.53
A 8	-------	0.04	0.13	0.73	0.45	3.09	2.53	0.25	0.83	6.81	1.49
A 11	1.39	0.08	3.66	0.33	0.84	2.70	1.68	2.36	0.79	1.39	1.52
A 12	0.04	0.47	2.75	0.87	-------	2.57	0.26	3.24	-------	1.51	1.17
A 13	0.37	0.17	4.58	2.00	0.10	2.75	0.09	3.53	0.04	7.54	2.12
A 14	-------	-------	0.27	0.10	0.10	2.56	0.44	2.36	0.18	5.55	1.16
A 15	2.06	0.17	2.75	4.83	0.18	1.75	0.35	2.51	0.16	2.50	1.73
A 23	-------	0.55	2.20	2.67	0.05	2.75	0.04	1.83	0.20	5.41	1.57
A 24	-------	-------	1.83	4.68	-------	2.37	0.21	2.56	0.62	0.39	1.27
A 99	1.43	0.21	0.18	3.42	0.05	2.80	0.38	6.92	-------	-------	1.54
B 114	0.30	5.29	0.42	6.95	0.23	0.91	5.61	2.79	0.74	1.74	2.50
B 132	5.94	4.39	0.21	19.88	-------	2.53	4.63	2.19	2.22	4.11	4.59
B 135	0.16	12.22	10.77	0.24	0.80	2.35	8.94	0.74	3.62	0.50	4.03
B 152	5.45	-------	0.23	3.94	1.03	2.15	2.31	2.12	0.43	8.56	2.62
B 157	-------	1.18	3.96	6.37	-------	2.81	0.50	0.45	4.47	-------	1.97

B 158	-------	0.68	6.02	8.78	0.23	2.18	1.74	3.16	2.03	0.55	2.54
B 213	0.39	0.06	9.48	-------	0.46	3.19	1.49	1.12	0.20	0.16	1.66
B 283	0.09	0.11	2.88	0.71	2.87	0.99	8.10	0.26	5.39	-------	2.14
B 304	0.79	0.45	1.47	0.95	4.94	3.80	2.88	3.53	0.55	0.69	2.00
K 2	-------	0.17	4.22	0.81	-------	1.84	2.02	2.78	2.17	-------	1.40
K 3	0.08	-------	7.08	1.34	-------	1.25	1.12	3.75	0.23	0.23	1.51
K 4	0.77	0.29	6.55	1.24	0.05	2.15	0.32	8.54	1.67	3.65	2.51
K 5	1.75	-------	7.49	1.44	-------	1.88	0.51	3.92	0.94	0.83	1.88
K 22	0.48	0.06	9.47	1.82	0.12	1.60	0.57	4.08	0.28	-------	1.85
K 23	1.61	-------	8.94	1.72	-------	1.70	1.16	7.51	0.60	2.17	2.54
K 31	0.64	0.17	14.02	2.70	0.14	1.59	1.21	4.95	0.26	1.03	2.67
K 34	0.15	2.41	10.18	1.96	-------	1.29	1.68	4.73	1.83	0.18	2.44
K 35	0.04	1.44	10.70	2.06	-------	1.40	0.58	5.71	0.04	0.12	2.21
K 36	-------	-------	1.33	0.26	-------	1.46	1.82	4.82	0.21	1.38	1.13
K 37	-------	-------	0.81	0.03	-------	1.52	1.66	4.90	0.51	0.47	0.93
S 24	0.03	3.27	0.02	0.77	6.94	5.45	1.58	4.29	0.39	5.80	2.85
S 31	0.44	0.23	1.12	0.28	0.39	6.04	3.41	3.72	-------	3.64	1.93

TABLE 5.—*Showing the average yields and average yield ratio of productive mandarin trees in orchards A, B, K, and scattered trees in Tanauan Citrus Station.*

Tree No.	Average production	Average yield ratio	Number years yield average	Remarks
B 114	258.2	2.50	5	
A 24	260.9	1.27	4	
A 23	262.6	5.57	5	
A 11	265.4	1.52	6	Selection 11.
A 12	265.7	1.17	4	
S 31	266.1	1.93	5	
B 152	268.6	2.62	7	Selection 9.
A 15	279.7	1.73	6	Selection 10.
B 283	280.2	2.14	4	
A 14	282.1	1.16	3	
S 24	288.6	2.85	6	Selection 12.
A 8	290.1	1.49	3	
A 7	291.3	1.53	4	
B 157	304.1	1.97	5	
B 304	329.8	2.01	5	
B 213	340.7	1.66	4	
K 3	346.9	1.51	5	
K 37	359.4	0.93	3	
K 36	368.8	1.13	5	
B 158	382.4	2.54	6	Selection 7.
A 13	404.9	2.12	5	Selection 8.
A 99	405.5	1.54	4	
K 22	410.7	1.85	4	
B 132	426.2	4.59	8	Selection 1.
K 2	433.4	1.40	5	
K 5	437.6	1.88	5	
K 35	447.2	2.21	5	
K 34	469.6	2.44	7	Selection 3.
B 135	483.6	4.03	5	Selection 6.
K 31	506.0	2.67	6	Selection 5.
K 4	607.8	2.51	6	Selection 4.
K 23	625.5	2.54	7	Selection 2.

A NEW DISEASE OF COTTON (*GOSSYPIUM* SP.) IN THE PHILIPPINES

By Feliciano M. Clara

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THREE PLATES

The possibilities of cotton growing in the Philippines in their various aspects have been the subject of no small number of treatises. However, the diseases of this plant appear to have received very little attention. Many of the recorded diseases in other countries are not known in the Philippines, but they could readily be introduced here with the introduction of seeds from foreign countries and local sources. This is especially the case when seeds are of doubtful origin and when they are produced without considering the factor of disease-freedom. Plants grown from such seeds offer a good means of detecting and intercepting disease transmitted in this manner. The cotton project of the Bureau of Plant Industry consisting of over forty varieties, hybrids and strains at the Central Experiment Station offered an opportunity for a study of this nature. With the exception of the varieties Batangas, "Kapas purao" and Keute, all of the other varieties, such as the Sakha, Ashmuoni, Sea Island and so on, which have been used as parent plants for breednig were imported from foreign countries

Periodical observations for the presence of diseases have been conducted since 1932. Within a short time angular leaf spot (*Phytomonas malvaceara, Bacterium solanacearum* Erw. Smith) reported by Reinking (1918), Anthracnose (*Glomerella gossypii* Edg.) and (*Colletotrichum gossypii*) reported by Welless (1921, 1922) were encountered. With these diseases other important ones not previously reported from the Philippines appeared on some of the plantings particularly on the varieties Sea Island and Ferguson. These diseases are commonly known as *Helminthosporium* blight, *Cercospora* leaf spot (*Cercospora althaeiana* Sacc.) club leaf (cyrtosis) and another leaf disease associated with *Alternaria sp.*

This brief report deals with the results of a study on the *Helminthosporium* blight. Recommendations on the control of important diseases of cotton transmitted by seeds are also included.

NATURE OF THE DISEASE

The leaves, bract and bolls are the most conspicuous parts of the plant attacked by the disease. On the plantings of the station the early symptoms were noted when the plants were 4 to 6

inches tall. On the leaves spots of various sizes and shapes are observed (Plate 1, fig. 1). They may be circular, zonated and sometimes irregular brown lesions on the margin of the leaves. The lower leaves show more of the disease, either due to the more favorable condition above the ground or due to the sources of infections and the conditions of the leaves. Which of these factors or combination of factors is mainly responsible for this seemingly more susceptible condition of the lower leaves was not determined. The spots may attain considerable sizes and very irregular shapes especially when two or more of them coalesce forming bigger spots. In the advance stage of the disease, the spots on the leaves may break off in a shot hole fashion. On the same diseased leaves other fungi belonging to the genera *Alternaria, Gloeosporium* and *Cercospora* are sometimes observed, but the *Helminthosporium* appears to be more abundant, especially at an early stage of the occurrence of the disease (Plate 1, fig. 2). In nature some of the lesions on the leaves may show distinct zonation concentrically formed (Plate 3, fig. *c*). On the bolls, spots of various sizes are observed (Plate 2). The badly diseased leaves are sometimes entirely involved and fall on the ground. The infected plants may show an impairment of their normal development as shown by the size of the plants and the time of flowering compared with varieties with little or no disease at all. The badly infected plants are stunted.

IMPORTANCE AND DISTRIBUTION OF THE DISEASE

Tucker (1926) first observed and reported this disease of cotton from Porto Rico, on Sea Island cotton plants. Later, the same disease was reported from the cotton growing region in the southern part of America. How it was introduced into the Philippines could not be ascertained. It is very probable, however, that it may have originated from infected pieces of plant parts introduced with imported cotton seeds.

In Porto Rico and in the cotton growing region of the Southern States of America this disease was reported as of economic importance. During the last two cotton seasons, the disease was studied and observed in the Central Experiment Station, Bureau of Plant Industry, Manila, as causing noticeable damages. Its occurrence in 1933 was more severe than in 1934 season. The plantings for these two years were not conducted on the same location, but the lot of the second year's plantings was closely adjacent to that of the previous year. No attempt at determining the causes of the variations in the virulence of the disease was made.

Fortunately the disease has not as yet been reported from other cotton growing regions of the Philippines. It appears very likely that its presence in the Central Experiment Station may have come with the newly introduced cotton seeds from foreign countries.

THE PATHOGEN

Pathogenicity.—A fungus associated with the diseased parts was isolated and cultured on a number of media. The organism reproduced the disease on cotton plants grown in pots and inoculated with bits of hyphae of the fungus. The inoculated plants were placed in a moist chamber, with a temperature of 20–30 ° C. for 48 hours. During the rest of the observations, the plants were kept in the greenhouse (green house with glass roof and wire mesh as walls). The results of the first series of inoculations are shown in Table 1.

TABLE 1.—*Showing the results of the first series of artificial inoculation on Ferguson var.*

Date	No.	Treatments	Observation after—		
			3 days	40 days	48 days
1933					
May 28	1	Inoculated with spore suspension	—	+	Small brown spot.
	2	do	—	+	Do.
	3	do	—	+	Do.
	4	do	—	—	—
	5	do	—	—	—
	6	do	—	+	Small brown spot.
	7	do	—	—	—
	8	do	—	+	Small brown spot.
	9	do	—	+	Do.
	10	do	—	+	Do.
	11	do	—	—	—
	12	do	—	—	—
	13	do	—	+	Small brown spot.
	14	do	—	—	—
	15	do	—	+	Small brown spot.
	16	do	—	+	+
	17	do	—	—	—
	18	do	—	+	Small brown spot.
	19	do	—	+	+
	20	do	—	+	+
	21	Control	—	—	—
	22	do	—	—	—
	23	do	—	—	—
	24	do	—	—	—
	25	do	—	—	—
	26	do	—	—	—
	27	do	—	—	—

Infections on the inoculated points with profuse growth of the fungus were observed in two days. The lesions were circular brownish but lacking the concentric ring observed on lesions found under natural conditions.

In the second series of infection studies, inoculations on leaves of all stages from the youngest to the lowest ripe leaves and on bolls, also of different ages, were conducted. All cultures used for inoculations were grown on potato dextrose agar. The results of these inoculations are shown in Table 2.

TABLE 2.—*Inoculation with Helminthosporium on leaves and bolls of cotton (Ferguson var.)* *

Date	No.	Condition of leaves at time of inoculation	May 31	June—			
				2	4	5	
May 29	1	8 injuries. Young pods	—	—	—	—	
	2	8 injuries. Maturing pods	—	—	—	—	
	3	8 injuries. Matured pods	+	+	+	100%	Suture opening.
	4	8 injuries. Matured pods. Sign of drying.	+	+	+	+100%	
	5	8 injuries. Matured pods	+	+	+	+100%	
	6	8 injuries. Matured	—	—	—	—	Control.
	7	8 injuries. Matured	—	—	—	—	Control.
ON LEAVES OF ALL STAGES FROM THE YOUNGEST TO THE OLDEST							
	9	10 points. Upper surface. Youngest open leaf.	—	—	—	—	
	10	10 points on upper and lower surface. Next young leaf down.	—	—	—	—	
	11	10 points upper surface. Next or third leaf down.	+?	+	+	+	
	12	10 points upper surface. Next or fourth leaf down.	+?	+	+	+	
	13	10 points lower surface. 10 points on edges of young leaf.	—	—	—?	—?	
	14	10 points lower surface on a young leaf.	—	—	—	—	

* A plus (+) sign means that infection has been obtained; a minus (—) sign indicates that no infection was obtained.

It may be noted that the matured leaves readily showed infections while the youngest leaves did not. This same manifestation was observed on the inoculations on bolls (Plate 2). The infections on the bolls at first appeared as circular spots slightly sunken, and dark brown but later assumed irregular shapes of

various sizes. The inoculations made near the suture showed a breaking up of the shell, eventually exposing the lint (Plate 2).

GROWTH ON MEDIA

The growth of the fungus was observed on potato dextrose agar, corn meal, potato plug and oat meal.

Potato dextrose.—Greyish to black growth is produced on this medium. Abundant aërial growth with many spores is observed in ten days.

Steamed corn meal.—The growth on this medium is very active, no less abundant than on potato dextrose agar. Aërial growth and spores are readily produced. Dark mycelial growth becomes more marked with age.

Steamed oat meal.—A very active growth similar to the growth on potato dextrose agar and steamed corn meal is produced. Spores are produced within 10 days.

MORPHOLOGY

The mycelium is colorless when young. Some of the mycelia from old cultures show dark brown color under the microscope.

Conidia.—The conidia vary in shape from clavate, curved or elliptic, to straight. The base shows the broadest diameter tapering upward to the apex (Plate 3, figs. *b, d, e*). They are colorless under the microscope. Measurements of the spores show a range of dimensions: 77–164.5 by 12–16 μ average size 115 x 13.3 μ. The number of septations observed range from 5 to 18. Fifty per cent of them are 6–9 septate.

Conidiophores.—The conidiophores are olive brown, single or in groups, 2 to 4 septate; dimensions ranging from 20–44 x 1.8–2.0 μ with an average measurement of 30.2 x 5.9 μ.

Comparison of Philippine *Helminthosporium* with the Porto Rico *Helminthosporium* as described by Tucker.

Philippine Helminthosporium	*Porto Rico Helminthosporium*
CONIDIA	
Extremes of meas: 77–164.65 x 12–6μ	Extremes of meas: 35–118 x 11.7–18.4μ
Average dimension: 115 x 14.3μ	Average dimension: 87 x 15.3μ
Class 70–115μ width 55 per cent	Class 70–115μ width 85 per cent
Class 13–17μ width 50 per cent	Class 13–17μ width 95 per cent
Range of septation = 5–18 50 per cent with 6–9 septation.	Range of septation = 1–8 85 per cent with 4–7 septation.

CONIDIOPHORES

Extremes of meas: 81–162.8 x 5.5–7.4μ	Extremes of meas: 40–185 x 6.5–8μ.
2–4 septation	1–5 septate
Single or in group olive brown. Variable in shape: straight, cylindrical to nodose or bent.	Single or in group of three brown variable, from straight, cylindrical to nodose or bent.

The morphological characters of the fungus when compared with those of *Helminthosporium gossypii* described by Tucker (1926) in Porto Rico showed some differences in the size of conidia and conidiophores. The conidia of the Philippine *Helminthosporium* gave extreme measurements ranging from 77–164.65 by 12–16μ while Tucker's organism gave a range from 35–118 by 11.7–18.4μ. The average dimension of the Philippine fungus is 115 by 14.3μ and the Porto Rican *Helmonthosporium* is 87 by 15.3μ. However, the majority of the measurements of conidia fall in the same class range with the *Helminthosporium gossypii* reported by Tucker. More septations are observed with Philippine *Helminthosporium* but the majority fall in the same class.

The dimensions of the conidiophores were also very variable. Those of the Philippine fungus gave extremes from 81–162.8 by 5.5–7.4μ, while the conidiophore measurements of the Porto Rican fungus is 40–185 by 6.5–8μ. The septations showed only a slight difference.

In physiological characters the two organisms are very similar. Considering the variability of the morphological characters of this organism and the close similarity of the two organisms in a number of important characters, the Philippine organism is referred to *Helminthosporium gossypii* Tucker.

CONTROL MEASURES

The following recommendations are known to be effective in the control of the important diseases of cotton carried by seeds:

1. Clean seeds free from particles that usually come with careless handling should be used for planting. Seeds for planting should be obtained from cotton bolls and plants with no symptoms of diseases.

2. Some of the diseases like anthracnoses are known to be starved out by storing the seeds in dry places for one to two years.

3. The bacterial blight or black arm (*Phytomonas malvacearum*) is controlled by hot water treatment of the seeds. This practice should be employed wherever practicable, but especially when the history of the origin of the seeds is not known, or of doubtful sources.

4. In any case the seeds should be delinted with concentrated sulfuric acid and then treated in hot water at 72° C. for 18 minutes (follow carefully the direction given by Walker (1930) to avoid mistakes and achieve the desired results.

5. A periodical inspection of the plantings to detect early infections should be conducted. Such practice accompanied by removal of infected plants or leaves may help in checking the diseases.

6. All introduced seeds should be grown in an isolated place for observation of diseases.

SUMMARY

1. A disease on cotton not before known to be present in the Philippines was found on introduced seeds of cotton.

2. The cause of the disease and its virulence as it occurred on the different varieties, hybrids and strains of cotton was observed.

3. The disease is caused by a fungus referred to as *Helminthosporium gossypii* Tucker.

4. Selection of seeds from disease-free plants, careful handling of the seeds and seed disinfection will greatly help in checking the disease.

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ILLUSTRATIONS

Plate 1

Fig. 1. Leaf showing the lesions infected with *Helminthosporium gossypii.* 7/10 of natural size.

2. A leaf of cotton (Ferguson variety) inoculated with *Helminthosporium gossypii.* Infections indicated by 1, 2, 3, 4, and 5. 7/10 of natural size.

Plate 2

Fig. 1. Cotton bolls (Batangas variety); right shows lesions (1, 2, 3, 4, and 5) due to natural infection with *Helminthosporium gossypii.* Collected from cotton plants grown in Silang, Cavite. April 27, 1934. 8/10 of natural size.

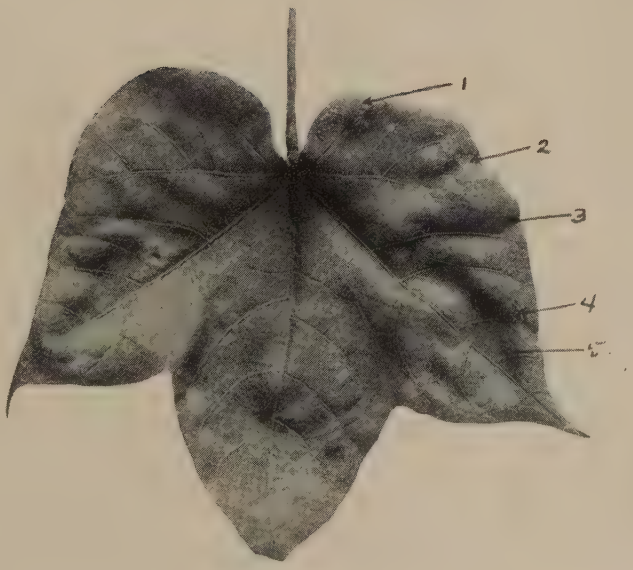
2. Cotton bolls (Ferguson variety) inoculated with *Helminthosporium gossypii* June, 1934. Fruit on the extreme left was used as check showing non-infected artificial punctures. 7/10 of natural size.

Plate 3

a. Leaf infected with *Helminhosporium gossypii* showing the lesions in one of the specimens collected at the Central Experiment Station, Manila, December 20, 1932. 2/5 of natural size.

b to *j.* Conidia and conidiophores of *Helminthosporium gossypii* from the lesions of the infected leaf. ×412.

1



2

PLATE 1.

1

2

PLATE 2.

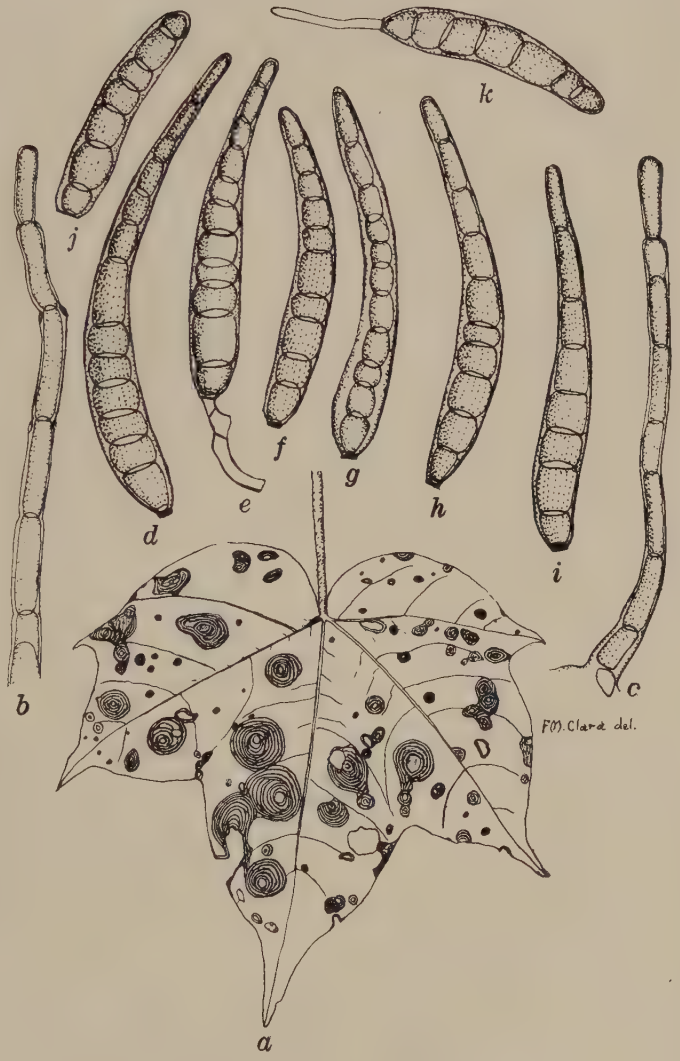


PLATE 3.

AGRICULTURAL ABSTRACTS

NITROGEN FIXATION STUDIES WITH FUNGI AND ACTINOMYCES

By FRANKLIN E. ALLISON, senior chemist; Sam R. Hoover, assistant scientific aid; and Herman J. Morris, assistant scientific aid; Biological and Organic Division, Fertilizer Investigations, Bureau of Chemistry and Soils, United States Department of Agriculture.

Experiments made with nine cultures of true fungi, including 8 strains of *Aspergillus* and 1 *Cladosporium* and with five species of common soil actinomyces, grown in various media, showed no nitrogen fixation.

"A critical consideration of all of the evidence on the subject indicated strongly that nitrogen fixation is, at most, limited to a very few species of the free-living fungi, and the data for these are certainly not conclusive. The evidence that certain mycorrhizal fungi can use atmospheric nitrogen, at least when growing in the roots of the host, is much stronger. (Adapted from the Journal of Agricultural Research, Vol. 49, No. 12, pp. 1115–1123, December 15, 1934.)

A STUDY OF THE COTTON ROOT-ROT FUNGUS (PHYMATOTRICHUM OMNIVORUM) IN THE SOIL BY THE CHOLODNY METHOD.

By E. D. EATON, junior pathologist; and C. J. KING, agronomist; Division of Cotton and Other Fiber Crops and Diseases. Bureau of Plant Industry, United States Department of Agriculture.

By the Cholodny technic which "consists in exposing standard microslides in the soil under field conditions" it has been observed that:

"(1) *Phymatotrichum mycelium* was active in the soil at least 6 weeks before the first symptoms were observed on nearby cotton plants.

"(2) The growth of the mycelium in the soil apparently was not connected with roots; and

"(3) The mycelium developed in a clean fallow."

The writer further suggested that the Cholodny technic may be used for:

(1) Biological and control studies.

(2) As a means of ascertaining the presence of fungus in fallow lands, and

(3) In studies of its interrelations with other organisms. (Adapted from the Journal of Agricultural Research, Vol. 49, No. 12, pp. 1109–1113, December 15, 1934.)

SOME MICROBIOLOGICAL ACTIVITIES AFFECTED IN MANURIAL CONTROL OF COTTON ROOT-ROT

By C. J. KING, agronomist; CLAUDE HOPE, junior horticulturist; and E. D. EATON, junior pathologist; Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, United States Division of Agriculture.

An experiment conducted at the United States Field Station, Sacaton, Arizona, since 1921, demonstrated the effectiveness of organic manures applied in deep furrows in controlling the cotton root-rot disease, *Phymatotrichum omnivorum* in irrigated lands. The following theories were advanced in explanation of the above results:

(1) The organic acids from the decomposing manure reduce the alkalinity of the soil and make it less favorable for the fungus;

(2) The evolution of ammonia in the manured plots inhibits or kills the fungus;

(3) The stimulation received by the fertilized plants gives them greater resistance;

(4) Many roots are caused to develop superficially and are thus able to escape the fungus attack;

(5) The manure increases the number and activities of competitive organisms which inhibit the growth and development of the root-rot fungus.

An investigation was made in 1933 to verify the fifth explanation above-mentioned. Comparisons of microbiological activities in 4 quarter-acre plots which had received applications of manure for several years with that of 5 alternate plots of the same size which received no manure, was made.

Comparisons between adjacent plots showed that the manured plots had 19 to 152 per cent greater evolution of CO_2 than the unmanured plots, indicating an activity of soil micro-organisms

in the decomposition of an increased content of organic materials.

It was also found, by the Cholodny method of direct microscopic examination, that bacteria and actinomycetes in various forms and most fungi were more abundant on the slides exposed in the manured plots. The root-rot fungus, *Phymatotrichum omnivorum,* was more abundant on the slides exposed in the unmanured plots.

The tests further showed that the population of many organisms is greatly increased by large applications of organic matter to the soil and that the dense populations or organisms engaged in breaking down the organic materials developed a soil condition temporarily unfavorable for the growth and activity of the root-rot fungus, causing a rapid and prolonged reduction of root-rot activity. (Adapted from the Journal of Agricultural Research, Vol. 49, No. 12, pp. 1093–1107, Dec. 15, 1934.)

TRANSMISSIBILITY BY APHIDS OF THE TOBACCO MOSAIC VIRUS FROM DIFFERENT HOSTS

The writer has previously presented evidence that aphids do not transmit the tobacco mosaic virus from tobacco to tobacco and other writers have also shown that extensive attacks may be adequately accounted for on the basis of other modes of infection and spread.

"In repeated tests of the ability of three species of aphids in large numbers to transmit the ordinary tobacco mosaic virus from various solanaceous and other hosts, transmission was obtained with regularity only from tomato (*Lycopersicum esculentum* and *L. pimpinellifolium*).

"In general, the greatest amount of transmission of the tobacco mosaic virus from any host was effected by *Myzus pseudosolani;* less infestation was obtained with *Macrosiphum solanifolii* and least with *Myzus persicae.*

"By transferring known numbers of aphids from tobacco-mosaic-diseased *Lycopersicum pimpinellifolium* to plants of the hybrid *Nicotiana tabacum* x *N. glutinosa* and counting the number of local lesions of tobacco mosaic produced, it was estimated that, with *Myzus pseudosolani,* about 1 aphid in 129 caused infection; with *Macrosiphum solanifolii* about 1 aphid in 140; and with *Myzus persicae* about 1 aphid in 800 or more. Comparative tests indicated that, in the transmission of a crucifer mosaic

virus by *M. persicae* to tobacco, 1 aphid in 4 or 5 acted as vector, and, in transmission of the sugar beet mosaic virus to tobacco by the same aphid, approximately 1 aphid in 4.

"It is concluded that the more common aphids probably do not transmit the ordinary tobacco mosaic virus from certain hosts, and only rarely or with great difficulty from other hosts. It not only seems unlikely that any appreciable amount of dissemination of tobacco mosaic may be brought about by aphids, except perhaps from tomato, but it is even doubtful whether much of the sporadic infection occurring on tobacco may be accounted for in this way." (Adapted from Hoggan, Iomi A. Transmissibility by Aphids of the Tobacco Mosaic Virus from Different Hosts. Journal of Agricultural Research, Vol. 49, No. 12, pp. 1135–1142, Dec. 15, 1934.)